MINISTRY OF
AGRICULTURE, FISHERIES AND FOOD

FOOD STANDARDS COMMITTEE
REPORT ON
PRESERVATIVES IN FOOD

LONDON
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1959

Food Standards Committee

The Food Standards Committee was set up in 1947. Its present terms of reference are:

> To advise the Secretary of State for Scotland, the Minister of Agriculture, Fisheries and Food, the Minister of Health, and as respects Northern Ireland the Secretary of State for the Home Department, on the composition, description, labelling and advertising of food, with particular reference to the exercise of the powers conferred on Ministers by Sections 4, 5 and 7 of the Food and Drugs Act, 1955, and the corresponding provisions in enactments relating to Scotland and Northern Ireland.

The following served on the Food Standards Committee during the preparation of this report:

Norman C. Wright, Esq., C.B., M.A., D.Sc., Ph.D., F.R.I.C. (*Chairman*)
G. G. Barnes, Esq., C.B.E. (*Vice-Chairman*)
C. A. Adams, Esq., C.B.E., B.Sc., F.R.I.C., Barrister-at-Law
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Professor B. S. Platt, C.M.G., M.Sc., M.B., Ch.B., Ph.D.
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G. Taylor, Esq., O.B.E., F.R.I.C.
R. F. Tyas, Esq.

Joint Secretaries:

M. D. M. Franklin, Esq.
W. M. Shortt, Esq., M.Sc., F.R.I.C.

Preservatives Sub-Committee

The Preservatives Sub-Committee was appointed by the Food Standards Committee in January, 1951, with the following terms of reference:

> To review the Public Health (Preservatives etc. in Food) Regulations and to make any recommendations the Sub-Committee may consider desirable for the amendment of the Regulations.

The following served on the Preservatives Sub-Committee during the preparation of this report:

Sir Charles Dodds, M.V.O., M.D., D.Sc., F.R.C.P., F.R.I.C., F.R.S. (*Chairman*)
C. A. Adams, Esq., C.B.E., B.Sc., F.R.I.C., Barrister-at-Law
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R. Tyas, Esq.

Joint Secretaries:

M. D. M. Franklin, Esq.
W. A. Godby, Esq., M.B.E., F.R.I.C.

The Sub-Committee's Pharmacology Panel consisted of the medical members of the Sub-Committee with the addition of Professor E. Boyland, D.Sc., and Professor G. A. H. Buttle, O.B.E., M.A., M.R.C.S., L.R.C.P.

The Sub-Committee have asked to have recorded their appreciation of the work done by the Secretariat who have made a very difficult task possible. In particular, they wish to thank Mr. Godby for all the help they have derived from his encyclopaedic knowledge and immense capacity for work and to pay a special tribute to Mr. Franklin's drafting skill.

FOOD STANDARDS COMMITTEE REPORT ON PRESERVATIVES IN FOOD

The Food Standards Committee have considered and adopted the report of the Preservatives Sub-Committee which follows.

The report completes the review of the existing Public Health (Preservatives etc. in Food) Regulations for which the Sub-Committee was set up in 1951.

Since the Regulations were framed in 1925, there have been many changes in the food industry relevant to a consideration of what control over the use of chemical preservatives is now desirable. After reviewing developments in food processing and packaging techniques, the Sub-Committee has concluded that some extension of the range of foods permitted to contain preservative is justified under modern conditions. Similarly, having considered the pharmacological evidence now available in respect of potential food preservatives (including antibiotics), some of which have only been developed comparatively recently, the Sub-Committee is satisfied that there are several substances in addition to those at present permitted which may safely be used. Nevertheless, the Sub-Committee reaffirm, in relation to the use of preservatives, the general principles which have guided them throughout their review, viz., that preservatives should only be employed in foods if their use has been expressly authorised; that additions should only be permitted where they have been shown to be necessary or advantageous, and then only in the amount needed to achieve the desired effect; and subject to the overriding requirement that the addition should not give rise to a health hazard.

These general principles are stated in Part I of the report. In Part II of the report the Sub-Committee has reviewed the operation of the existing Regulations from the enforcement angle and made a number of recommendations mainly designed to clarify their scope and application and to take account of changes in other food and drugs legislation. Parts III and IV contain the detailed discussion and recommendations regarding substances proposed for use as food preservatives and the foods in which it is suggested that preservatives should be allowed.

While the basic approach of the existing Regulations accords with the Sub-Committee's general principles, implementation of the recommendations will involve recasting the provisions of the Regulations themselves and major changes in the Schedule which details the foods which may contain preservatives and the nature and amount of preservative permitted. If the recommendations are accepted, all the foods at present in the Schedule will continue to be allowed to contain preservative, although modifications are suggested in the provisions applying to fruit pulp and other fruit products, soft drinks, and pickles and sauces. The provisions relating to the treatment of citrus fruit have already been altered in accordance with the Sub-Committee's recommendations; changes are also suggested in the present provisions for cured meats. The more important additions to the Schedule will be provision for bread to contain propionic acid; for flour confectionery, cheese and certain food adjuncts to contain sorbic acid; and for various canned foods and cheese to contain the antibiotic, nisin. The methyl or propyl esters of parahydroxybenzoic acid will also be permitted as an alternative to benzoic acid in certain cases. Unlike the present Regulations, provision is made for the use of more than one permitted preservative where a mixture may have advantages.

Details of the proposed new Schedule together with a summary of the Sub-Committee's other recommendations will be found in Part V of the report.

REPORT OF THE PRESERVATIVES SUB-COMMITTEE

TABLE OF CONTENTS

PART I Historical introduction and statement of general principles (paragraphs 1–23)

PART II Proposals for amending the general form of the regulations (paragraphs 24–59)

PART III Consideration of the properties of chemical preservatives and their possible effects on health (paragraphs 60–152)

PART IV Consideration of the case for permitting preservative in individual foods (paragraphs 153–299)

PART V Summary of recommendations. This includes a list of scheduled foods showing the permitted maximum amounts of preservatives

APPENDIX I List of organisations which have submitted representations to the Sub-Committee

APPENDIX II Annotated bibliography of work cited in PART III of the report

APPENDIX III Estimation of dietary intake of sulphur dioxide

APPENDIX IV Report of the Antibiotics Panel

PART I: INTRODUCTION

1. We were appointed as a Sub-Committee of the Food Standards Committee in January, 1951 to:

> "review the Public Health (Preservatives etc. in Food) Regulations and make any recommendations considered desirable for the amendment of the Regulations".

2. As a basis for consideration, we received a memorandum from a Joint Committee representing the then Society of Public Analysts and Other Analytical Chemists and the Food Group of the Society of Chemical Industry.*

3. Because of the wide range of substances covered by our investigations, we decided to report on each class of substance separately. Reports on antioxidants (1954), colouring matters (1954 and 1955) and emulsifying and stabilising agents (1956) have already been published. The present report deals primarily with preservatives, i.e., those substances which inhibit or prevent the growth of bacteria, yeasts or moulds in food; but since this report completes our review it also deals with some of the general issues arising from the existing Public Health (Preservatives etc. in Food) Regulations† (subsequently referred to as the Preservatives Regulations) and includes our detailed recommendations for amending them.

4. The Departmental Committee on the Use of Preservatives and Colouring Matters in Food, which reported in 1924‡, enunciated the following propositions:

- (i) that it is undesirable to add to articles of food any material not of the nature, substance and quality of food;
- (ii) that if for commercial or other reasons the addition is necessary, it should be limited to the minimum required to effect its purpose;
- (iii) that if it can be shown that some of these materials are less undesirable than others, preference should be given to the employment of the less undesirable materials.

5. In the light of these propositions, the Committee recommended that the only preservatives permitted in food should be sulphur dioxide and benzoic acid, and these only in a limited number of foods. The emphasis in the Report was that, except in a very limited number of cases, the use of chemical preservatives would be unnecessary if strict attention were paid to hygiene during manufacture and adequate facilities for storage and transport at low temperatures were available.

6. The Committee's recommendations on preservatives were substantially adopted and the Preservatives Regulations framed accordingly. In substance, they prohibit the sale and the manufacture or importation for sale of any

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*This memorandum was published in *The Analyst*, 1951, Vol. 76 Page 276.

†The Public Health (Preservatives etc. in Food) Regulations, S.R. & O. 1925, No. 775, as amended by 1926, No. 1557; 1927, No. 577; 1940, No. 633; and S.I. 1953, No. 1820; and the Public Health (Preservatives etc. in Food) Regulations (Scotland), S.R. & O. 1925, No. 814 (S.59) as amended by 1926, No. 1603 (S.50); 1927, No. 623 (S.35); 1940, No. 649 (S.24); and S.I. 1953 No. 1859 (S.125). (See also footnote, page 3.)

‡The Committee issued an Interim Report on the Treatment of Chilled Beef and Other Foods with Formaldehyde and a Final Report on the use of Preservatives and Colouring Matters in Food (H.M.S.O., 1924).

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article of food containing added preservative except that:

(i) foods specified in Part I of the First Schedule (subsequently referred to as Scheduled foods) may contain preservative of the nature and in the proportion specified;

(ii) where a Scheduled food (other than Item 4 of the Schedule) containing preservative of the nature and amount permitted is used in the preparation of any other food, the latter may contain any preservative necessarily introduced by the use in its preparation of the Scheduled food.

7. No restriction was placed on the old established practice of preservation by smoke-curing or on the use in the preparation of foods of a few common substances which may have some preservative action. Such substances are specifically excluded from the definition of "preservative" given in the Regulations, viz:

> "Preservative" means any substance which is capable of inhibiting, retarding or arresting the process of fermentation, acidification, or other decomposition of food or of masking any of the evidences of putrefaction; but does not include common salt (sodium chloride), saltpetre (sodium or potassium nitrate), sugars, lactic acid, acetic acid or vinegar, glycerine, alcohol or potable spirits, herbs, hop extract, spices and essential oils used for flavouring purposes or any substance added to food by the process of curing known as smoking.

8. Of the Scheduled foods, sausages, sausage meat, butcher's minced meat (in Scotland), coffee extract, pickles and sauces, and grape juice and wine (when containing over 600 parts per million (p.p.m.) of benzoic acid) are required to carry a declaration of the presence of the preservative in a special form. The Regulations also contain provisions in respect of the labelling and advertising of articles sold as preservatives.

9. In 1940 the Regulations were amended so as to permit the addition of sodium or potassium nitrite to bacon, ham and cooked pickled meat. A maximum limit of 200 p.p.m. (calculated as sodium nitrite) was set in the case of cooked pickled meat.

10. Under emergency powers* the Regulations were substantially relaxed to meet war-time conditions and the period of control which followed the war. A number of foods were permitted to contain a preservative without statutory limit, although control was exercised administratively by the Ministry of Food, and in some cases limits were imposed by licence. The relaxations are summarised in the table on page 3.

11. The provision allowing the use of borax in bacon was revoked in December, 1950, and those relating to meat and margarine in 1953. The Preservatives Regulations were amended in 1953 so as to continue the permissive use of preservative in dehydrated vegetables, the higher limit for sulphur dioxide in jam and the use of diphenyl-impregnated wraps for citrus fruit. It was made clear at the time that the incorporation of these provisions was without prejudice to our review of the Regulations as a whole.

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*Regulation 60CAA of the Defence (General) Regulations, S.R. & O. 1944, No. 1311-13.

Amendments made under Regulation 60CAA of the Defence (General) Regulations

Food	*Preservative allowed*	*Limit set by licence*
Meat	Sulphur dioxide	Not practicable to prescribe a limit because of the mode of application.
Margarine	Borax	0·25% (expressed as boric acid).
Bacon	Borax	Not practicable to set a limit but only permitted in imported produce.
Dehydrated vegetables	Sulphur dioxide	500–3,000 p.p.m. according to species of vegetable.
Jam	Sulphur Dioxide	100 p.p.m. (instead of the 40 p.p.m. permitted in the Preservatives Regulations).
Citrus fruit	Diphenyl	Impregnated wrapping to contain not more than 40 mg. per 100 sq. in. of wrap.

12. The existing legal position* may therefore be summarised as follows:

(i) The articles of food enumerated in the amended Part I of the First Schedule to the Preservatives Regulations may contain sulphur dioxide or benzoic acid in the amount specified.

(ii) Bacon, ham and cooked pickled meat may contain added sodium or potassium nitrite; no limit is prescribed for bacon and ham but the maximum permitted in cooked pickled meat is 200 p.p.m. (calculated as sodium nitrite).

(iii) Citrus fruits may contain diphenyl from the use of diphenyl-impregnated wraps.

(iv) Any compounded food may contain that amount of preservative necessarily introduced by the use in its preparation of a food (other than Item 4 of the Schedule) permitted to contain preservative of the nature and in the amount prescribed.

13. The Preservatives Regulations now in force are thus substantially those laid down in 1925–27 with comparatively minor modifications resulting mainly from war exigencies. The extensive changes in methods of food manufacturing and

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*During the preparation of this report, the Sub-Committee was asked by Departments to give priority consideration to the treatment of citrus fruit with diphenyl and o-phenylphenol and the treatment of non-citrus fruit with o-phenylphenol. As a result, the Sub-Committee's recommendations on this subject (which appear in paragraphs 227-232 and 265 of the report) were communicated to Ministers in advance of the publication of this report. After considering these recommendations, Ministers made the Public Health (Preservatives etc. in Food) (Amendment) Regulations, 1958, No. 1319 and the Public Health (Preservatives etc. in Food) (Amendment No. 2) Regulations, 1958, No. 2167, and corresponding regulations for Scotland. The first amending regulations permit citrus fruit to contain up to 100 p.p.m. of diphenyl or 70 p.p.m. of o-phenylphenol or appropriate admixture of these two. The other amending regulations provide for the presence of o-phenylphenol in apples, pears and pineapples up to 10 p.p.m., in peaches up to 20 p.p.m. and in melons up to 125 p.p.m. In all these cases there is provision for the carry-over of these preservatives into foods containing fruit, except that in the case of melons, the tolerance for the purposes of calculating the permissible carry-over is limited to 10 p.p.m.

retailing, the introduction of new techniques for preserving food and the many advances in food chemistry and technology which have taken place over the last thirty years indicate the need for modifications. The fact that we have felt it necessary to deal separately and at some length with three classes of food additives before considering preservatives, is an indication of the growing complexity of the problem of regulating the use of food additives in the public interest.

14. That there is need for changes in the law relating to the use of preservatives is also evidenced by the volume of representations we have received from the food and chemical industries. A list of the organisations which have given evidence appears in Appendix I.

15. We have received many requests that the use of new preservatives should be allowed and that foods not at present permitted to contain a preservative should now be allowed to do so. Each of these requests has been carefully considered and our conclusions are set out in detail in later sections of this report. It will, however, be convenient at this point to set down certain principles with which we approached this review and some general conclusions we have arrived at during the course of it.

16. At ordinary temperatures most foods are subject to the deteriorating activity of bacteria, yeasts and moulds.* It is important not only to ensure that foods reach the consumer in as wholesome, nutritious and palatable a form as possible but also to reduce wastage of food due to its deterioration. Everything possible should be done to reduce the time during which foods are exposed to conditions which may accelerate the process of deterioration. Physical means of preservation such as refrigeration, heat pasteurisation or sterilisation should be used wherever possible. Nevertheless, it must be recognised that such treatment is not always practicable or sufficient. Some use of chemical preservatives in food is therefore necessary, but we believe there are good reasons why their use should continue to be controlled.

17. In the first place, many substances known to be effective preservatives are not free from objection on health grounds. The relevant evidence is discussed in Part III of our report. Besides the toxicity of the preservative itself, possible effects on the nutritive value of food have also be to considered. For instance, sulphur dioxide will stabilise vitamin C but may destroy vitamin B_1.

18. Dangers which have long been recognised are that chemical preservatives may be used as a substitute for good hygiene in the factory or shop, or to mask incipient putrefaction so that the consumer is deceived as to the apparent wholesomeness of the food. The improvement which has taken place over the past years in general standards of hygiene in the food industry and the measure of statutory control now exercised through the Food Hygiene Regulations† mean that these risks are now much less than they were formerly. They nevertheless exist and provide a sound argument for continuing to exercise careful control over the circumstances in which preservatives may be used.

19. An argument which is sometimes brought forward against the use of chemical preservatives is that they may increase the risk of food poisoning by destroying spoilage organisms, the growth of which make it obvious that the

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*There are other causes of deterioration—oxidative rancidity, browning, etc.—with which we are not here concerned.

†S.I. 1955, No. 1906 and S.I. 1959, No. 413 (S.16).

food is unsound, while not destroying pathogenic organisms to a corresponding extent. While there are possibilities of selective action of this kind, it would be misleading to generalise. There is no evidence to suggest that it has been a serious danger during the currency of the existing Regulations. The foods allowed to contain benzoic acid generally have a sufficiently acid reaction to inhibit the growth of pathogenic bacteria and the same applies to several of the foods allowed to contain sulphur dioxide. Others have a different inhibitory factor such as a high sugar or a low moisture content. Sausages and sausage meat are an exception and at our request special tests were made by the Public Health Laboratory Service which gave no indication that the use of sulphur dioxide allowed the growth of pathogenic organisms at the expense of spoilage organisms; indeed there appears to be a tendency for salmonellae to be destroyed in the presence of sulphur dioxide. Nevertheless, we have had in mind the possibility of selective action when considering proposed new preservatives and proposals for extending the use of existing preservatives to other classes of food.

20. Finally, in considering the possible hazards associated with the use of preservatives, it is important to have regard to the food or foods in which they are used. Any possible adverse effects are likely to be greater and more serious with foods such as bread, meat, fish, milk and fresh fruit and vegetables which may be consumed daily in substantial amounts than with foods eaten only occasionally in small quantities. For this reason we have been particularly critical of proposals to add preservative to any such staple foods.

21. In the light of the above considerations we are of the opinion that the use of preservatives in food should only be approved when it has been shown that advantages are likely to accrue, whether they are technical, economic or otherwise, which will outweigh possible disadvantages associated with any of the considerations we have outlined. Furthermore, we consider that the general method of control at present in force (i.e. prohibition of the use of any preservative unless expressly permitted in specified foods and in limited amounts) provides the best means of safeguarding the consumer. In earlier reports* we have argued the case for specifying the substances which may be permitted rather than merely prohibiting the use of substances known to be harmful. We consider these arguments are valid here. We also believe there is ample justification for allowing preservatives in specified foods only, rather than having a blanket provision for all foods.† Finally, we consider that limits should be retained on the amount of preservative which may be present, mainly because of the possible adverse effects which might follow the ingestion of excessive amounts.

22. With the increase in refrigeration capacity in shops and elsewhere, the development of quick-frozen foods and the improved standards of hygiene, the case for permitting chemical preservatives in food might apear to be weaker now than when the Regulations were framed in 1925. But other developments such as the increased sale of ready-prepared or cooked foods and the widespread adoption of pre-packaging have told in the opposite direction. Furthermore,

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*See, for example, the Report on Emulsifying and Stabilising Agents (H.M.S.O., 1956), paragraphs 27 and 28.

†This contrasts with the law in Canada where any food may, for example, contain up to 1,000 p.p.m. of benzoic acid, unless it is a standardised food, in which case only what is specifically provided for may be used.

new preservatives have been introduced which appear to be even less objectionable than sulphur dioxide and benzoic acid. On balance, therefore, we have reached the conclusion that some extension in the use of preservatives is justified.

23. Further advances in food technology and methods of handling will undoubtedly continue, perhaps even at a faster rate. Wholly new methods of food preservation may be developed, as is indicated by the widespread interest already being shown in the possibilities of ionising radiations. In previous reports we have made proposals whereby our recommendations might be reviewed. This has been generally welcomed by trade and other interests and it has been represented to us that similar provision should be made for preservatives. We concur in this view, and recommend that some suitable machinery should be created for keeping the situation under review and for advising on such changes in the law as may be necessary from time to time.

PART II: PROPOSALS FOR AMENDING THE GENERAL FORM OF THE REGULATIONS

24. In this Part of the report we examine the general framework of the present Regulations and recommend changes which should be made. We do not attempt to suggest the precise legal terms in which the regulations should be couched, except in so far as this may be necessary to make our intention clear, but rather to express our recommendations in a form in which, if accepted, they can be translated into statutory terms by the legal draftsmen.

25. As indicated in paragraph 6 above, the basis of the present Regulations is a prohibition on the manufacture for sale, the importation for sale or the sale of any article of food which contains an added preservative, except in the circumstances provided for in the Regulations. The meaning of "food", "sale" and "preservative" in this context is defined.

26. **Definitions.** It will be convenient if we deal first with the definition of "preservative", since this determines to a very large extent the scope of the Regulations. In general, the present definition of a preservative has proved sound and afforded an important measure of protection for the public. It is, however, an extremely wide one, and were it not interpreted with good sense by enforcing authorities, it could have the effect of extending the prohibition on the addition of substances to food far beyond the category of those which would normally be regarded as food preservatives and beyond what the 1924 Committee had in mind.* The possibility of this wide application arises principally because the definition refers to substances which are *capable of* producing one or more of the effects enumerated. Without any qualification regarding the concentration or circumstances in which the substance is used, it is clear that a great many substances which are not usually regarded as preservatives could thus be brought within the ambit of the definition. It has been suggested that one way out of the difficulty would be to alter the definition in such a way as to take account of whether the substance is present in the food in sufficient quantity to have a significant preservative effect. We do not, however, favour this alteration, which we think would lead to great difficulties in enforcement and hence seriously weaken the effectiveness of the regulations. If such an alteration is not made, however, it may be desirable to make explicit reference to certain

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*See paragraph 27 of the Report of the Departmental Committee.

classes of substances which have not so far been regarded as preservatives but which might strictly speaking be held to come within the scope of the existing definition. In indicating those which, in our view, it would be inappropriate to include within the scope of amended Preservatives Regulations, we imply no judgment as to whether or not it may be necessary or desirable to control their use under other regulations.

27. In the first place, reference should be made to those chemicals which are used in agriculture and food storage for the control of pests and other purposes. The treatment of crops in this way may leave a residue on the food when it is offered for sale for human consumption. The possible risks to the consumer arising in this way are among the aspects studied by the Advisory Committee on Poisonous Substances used in Agriculture and Food Storage. Exemption from the scope of the Preservatives Regulations might extend to the post harvest treatment of crops for insecticidal and similar purposes but not to forms of treatment (such as the dipping or wrapping of fruit in diphenyl) clearly designed to control the growth of moulds or other forms of microbial deterioration in foods ready for sale to the consumer.

28. Secondly, to ensure that the Regulations would not be held to apply to harmless additives expressly permitted in food for other purposes (which might otherwise be held to be preservatives as defined), it would seem necessary to exclude permitted colouring matters, antioxidants, and emulsifying and stabilising agents (assuming our recommendation for a permitted list of these additives is accepted).

29. It is also desirable to clarify the position of certain classes of food additives not at present subject to regulation. The existing definition of 'preservative' expressly excludes glycerin and ethyl alcohol but the trade has indicated that the following substances are also currently in use as solvents for food additives: iso-propyl alcohol, propylene glycol, diethylene glycol, mono-ethyl ether, hexylene glycol, monoacetin, diacetin and triacetin. Similarly, the definition excludes "herbs, hop extract, spices and essential oils used for flavouring purposes" and it is known that a large number of natural and synthetic flavouring substances are in use. We have not attempted to consider either of these classes of substance for their suitability as food additives from the pharmacological or any other point of view; we consider that they are outside the scope of the Preservatives Regulations and should be so recognised.

30. Having indicated these general reservations, we now deal with specific proposals for amending the present definition and the list of common preservatives which are expressly excluded.

31. The Report of the Joint Committee (see paragraph 2) recommended that the word "decomposition" in the present definition should be replaced by the word "deterioration". This suggestion would widen the scope of the definition even further since decomposition is only one of the many ways in which food can deteriorate, and appears to have been based on the assumption that the Preservatives Regulations might be revised to embrace all the main classes of food additives. But provided it is clear that what is in mind is deterioration due to the action of bacteria, yeasts or moulds, we consider there would be merit in using the more comprehensive term.

32. The Report of the Joint Committee also suggests that all exceptions to the definition should be put into the Schedule, but we consider that the mention of such exemptions in the definition is a convenient way of allowing the use without

restriction of innocuous substances like salt and also of removing doubt as to whether certain substances are or are not to be regarded as preservatives. However, because the unrestricted use of any such additive may be undesirable for reasons discussed in Part I of our report, and because it is unsafe to assume that a substance which has been widely used for a long time is necessarily harmless, we think that this list of exemptions should be kept as short as possible. In particular, we recommend, for reasons discussed in Part III (paragraphs 80 to 82) that "saltpetre" should be deleted from this list and its use be restricted to the curing of meat by appropriate provision in the Schedule.

33. For the sake of removing any doubt as to their legal position, we suggest that the exemptions should include carbon dioxide and nitrogen when used for packing food in hermetically sealed containers, and acid calcium phosphate. It has been suggested that other phosphates and substances such as citric acid, sodium citrate and saccharin should similarly be specifically excluded as they might conceivably be held to be preservatives by definition. But since these substances have not been demonstrated to have preservative action and are commonly used in foods for quite different purposes, we do not consider that this should be necessary.

34. We have been specifically asked to express an opinion on two forms of treatment which might possibly be held to contravene the Preservatives Regulations. The first is the use of nitrous oxide in machines for dispensing whipped cream. Although moist nitrous oxide under very high pressures has been shown to have a marked bactericidal action, at the much lower pressure employed in making whipped cream there is no evidence of bactericidal effect. It should not, therefore, in our view, be regarded as a preservative. The Pharmacology Panel considered whether the practice was objectionable on health grounds but, as indicated in Part III, paragraphs 135–137, were satisfied that it presented no hazard.

35. Secondly, our attention has been drawn to practices of comparatively recent development involving direct contact of food with chlorinated water; these are distinct from long-established uses of chlorinated water to sterilise equipment and for general hygiene. One is the so-called "in-plant" chlorination of water in canning factories. Water chlorinated to give a free chlorine content of 4–7 p.p.m. is continuously applied to cannery equipment such as peelers and conveyors. Any chlorine taken up by the food from the chlorinated water is eliminated in the sterilisation process. We also understand that no off-flavours have been produced. Another use is in washing fresh fruit and vegetables to remove soil and other possible sources of micro-organisms, especially prior to pre-packaging of the produce. Again, the free chlorine can be expected to disappear rapidly in the presence of the organic matter. Provided the extent of chlorination is controlled to ensure that the produce as sold to the consumer contains no free chlorine, we see no reason to bring its use as a processing and hygiene aid within the scope of the Preservatives Regulations.

36. With regard to other definitions, it will clearly be desirable to bring those for "food" and "human consumption" into line with the meaning now ascribed to them in the Food & Drugs Act, 1955 (section 135). Similarly, "sell" should include (as it does in the remainder of this Part of our report) offer, expose or advertise for sale.

37. **Retail Sales.** From the point of view of consumer protection, the important point is what the food may or may not contain at the time it is sold to the

consumer. How the preservative comes to be there—whether by direct addition to the food, by being absorbed from a wrapper, or by accident, e.g. when the equipment being used to process the food has been washed with a solution containing the preservative—is largely irrelevant. Thus the offence should, in our view, be the sale of a food *containing* a non-permitted preservative or a permitted preservative in excess of the amount specifically allowed. This would remove the doubt which at present arises as to what constitutes the "addition" of a preservative. For instance, it would clearly permit the sale and use of wraps impregnated with permitted preservative as long as the necessary precautions are taken to ensure that their use does not result in the food containing a preservative which it is not permitted to contain or an amount in excess of that permitted. If the recommendation is accepted, it will be necessary to provide a defence for the seller if he can show that the preservative present has not been added but is natural to the food (e.g. benzoic acid in cranberries).

38. Similarly, we do not think the offence of "manufacture for sale" should be retained. Besides being largely unenforceable, it may in fact be inapplicable to certain cases where substances which could be held to be preservatives are added to food but are not demonstrably present, in the same or some other form, in the food as sold for consumption. Such practices remain subject to the general provisions of the Food and Drugs Acts and could be the subject of special regulation under Ministers' power to control processes, if any of them were shown to involve a health hazard to the consumer or to produce any other deleterious effects.

39. **Intermediate sales.** While it is proper to focus attention primarily on the composition of the food as it is finally sold for consumption, some control over it during the processes of manufacture and distribution may nevertheless be necessary for the greater protection of the consumer and for the sake of adequate enforcement. At present, the Regulations apply to all sales whether retail or not, except that, in the case of sulphur dioxide only, exemption is allowed (other than for meat) if it can be shown that, in the case of a non-Scheduled food which contains sulphur dioxide, it is intended to be used in the preparation of a Scheduled food or, in the case of a Scheduled food (except fruit and fruit pulp), it is intended to be so treated before it is sold by retail as to comply with the limit for sulphur dioxide in the Schedule. It is not known to what extent use is made of this proviso, but we understand that very little attempt is made to enforce the precise terms of it in practice.

40. In our view, a more satisfactory way both from the point of view of enforcement and the convenience of manufacturers would be to provide that food sold other than by retail must conform to the requirements for retail sale unless the food (not being one which is already pre-packed for retail sale) is accompanied by a statement of the actual content of the permitted preservative. We would expect this concession to be used mainly with foods containing sulphur dioxide which can readily be processed so as to reduce the sulphur dioxide content. But it has been represented to us that similar provision should be made for other cases, particularly concentrates used in the manufacture of soft drinks, where it would be of assistance to manufacturers were they allowed to include sufficient benzoic acid to preserve the soft drinks as prepared for sale. The above proposal would permit this while at the same time helping the manufacturer to ensure that the concentrate is sufficiently diluted or otherwise processed before it is sold by retail (or sold in any way without a declaration of

preservative content) to bring the preservative content within the prescribed limit. It will similarly assist in enforcement, since if a food sold by retail is found to contain an excessive amount of preservative and the supplier of the raw material can show that he gave a correct statement of the preservative content to the processor, responsibility for the offence can be clearly attributed to the processor.

41. If our recommendation is adopted, it will be necessary to prescribe in detail the manner and form of the declaration. This proposal will not apply to fruit and fruit pulp containing sulphur dioxide sold other than by retail for which we recommend a separate provision. This is discussed in Part IV of our report, paragraphs 157 to 162.

42. **Imported Food.** We recommend that the same provisions as for intermediate sales should apply to imports of food. Thus it should be an offence to import any food containing a non-permitted preservative or a food containing an excessive amount of a permitted preservative, unless (except in the case of fruit and fruit pulp and pre-packed foods ready for retail sale, to which this does not apply) the food is accompanied by a quantitative statement of the preservative content.

43. **Condemnation of Food.** We consider that the regulations should include, under the powers now given to Ministers in Section 4(4) of the Food and Drugs Act, 1955 and the corresponding provision in the Food and Drugs (Scotland) Act, 1956, a provision that any food sold or imported containing a non-permitted preservative may be treated as unfit for human consumption for the purpose of Section 9 of the Food and Drugs Act, 1955 (and Section 9 of the Scottish Act) under which food may be seized and destroyed on the order of a justice of the peace. We do not consider that it would be appropriate to invoke this provision where a permitted preservative is found in a food not permitted to contain a preservative or where a food permitted to contain a preservative is found to contain an excessive amount of that preservative. In such cases, the food and drugs authority will still be free to apply to a justice of the peace for condemnation of the food under the ordinary operation of Section 9 if the circumstances appear to warrant it.

44. **Mixed Preservatives.** The 1924 Departmental Committee recommended that the addition of two preservatives to a single article of food should be prohibited. This principle was adopted in the Regulations and where, as with soft drinks, a choice of sulphur dioxide or benzoic acid was given, they were not allowed in admixture.

45. We have received representations from several trade associations that, where a Scheduled food may be preserved with either of two preservatives, it should also be allowed to contain the two preservatives in appropriate quantities.

46. We can see no good reason why, if there is some advantage to be gained thereby, two permitted preservatives should not be allowed in a single food provided each preservative is unobjectionable and the total amount present is not excessive. We have adopted this principle in considering individual foods and, where there seems to be a case for allowing the use of mixed preservatives, have recommended accordingly (see Part IV). In such cases, our recommendation with regard to limits is that, where both preservatives are present, the amount of each should be such that, when expressed as a percentage of the amount permitted singly, the sum of the two does not exceed 100. For example, if a food is permitted to contain 200 p.p.m. of preservative A or 500 p.p.m. of

preservative B, the manufacturer could use, say, 100 p.p.m. of A and 250 p.p.m. of B (50% of the limit in each case) or 150 p.p.m. of A and 125 p.p.m. of B (i.e. 75% of the limit for A and 25% of the limit for B).

47. **Carry-over Provision.** Some provision must be made for the presence of preservative in a compounded food due to the use of an ingredient permitted to contain a preservative. At present, this is secured by Article 4(I)(ii) of the Regulations which states that "where an article of food specified in Part I of the said Schedule (a "Scheduled Food") otherwise than in item 4 thereof (specially labelled unfermented grape juice) is used in the preparation of any other article of food, the latter article may contain any preservative necessarily introduced by the use of the former article, but the total proportion of any one preservative contained in an article of food specified in that Part of the Schedule shall not exceed the proportion therein specified".

48. For the future, we consider it would be sufficient to provide that any compounded foods which contain one or more Scheduled foods as ingredients may contain preservative or preservatives permitted in the Scheduled foods in proportions appropriate to the amounts of Scheduled foods present.

49. For reasons explained in paragraph 184, this provision should not apply to fruit and fruit pulp for manufacturing purposes. We also suggest that the present item 4 of the Schedule should continue to be excluded since these products are unlikely to be constituents of another food.

50. If the recommendation about mixed preservatives is accepted, there would appear to be no necessity for the provision suggested in paragraph 48 to apply to Scheduled foods themselves. This should be made clear in any revised Regulations since the position of such foods at present is uncertain due to an ambiguity in the wording of Article 4(I)(ii).

51. **De Minimis Provision.** In view of the attitude we have taken in regard to the definition of preservative (see paragraph 26 above), we have given careful consideration to a suggestion that, as a means of dealing with the presence in food of traces of a permitted preservative which is present for some other reason or with some other object than the preservation of the food and is in fact present in too small an amount to have any preservative action, a limit be included in the Regulations such that, if the preservative was found to be present in the food in lesser amount, the food would not be regarded as containing a preservative and the Regulations would not apply.

52. Such a provision would have undoubted advantage. It could avoid the necessity of including a number of foods in the Schedule which contain a preservative (for instance, the small amount of sulphur dioxide picked up by some sugars in processing, or in beer due to sulphiting of the casks), with the implication that they are "preserved", when the amount present has little or no preservative action. A tolerance for all foods would at the same time ease the problem of analytical control and safeguard manufacturers from the risk of prosecution for what might be regarded as a purely technical offence.

53. On the other hand, there would be serious disadvantages. A *de minimis* limit of this kind would mean that, in theory at any rate, every food might contain some preservative. The resulting contribution to the total amount taken in the diet could be appreciable and this might make it difficult to reconcile the genuine needs of traders with the proper protection of the public. Moreover, some of the practices we have in mind result in a not insignificant amount of preservative being present. If a tolerance were generally applicable, the amount

might have to be high enough in such foods as to have a preservative action in others. A series of limits for different classes of food would largely defeat the object of such a provision.

54. On balance, we think it would be unwise to include an overall provision of this kind. So far as we are aware, the absence of such a provision in the existing Regulations has not given rise to any real difficulties. Cases where small amounts of preservative are necessarily introduced into foods are therefore dealt with in our recommendations for a revised Schedule. In any marginal cases where a minute trace of a permitted preservative such as sulphur dioxide may be present adventitiously, the food and drugs authority has discretion to decide whether any action by way of warning notice or legal proceedings is justified.

55. While we reject the idea of a *de minimis* provision for permitted preservatives generally, we think it would simplify enforcement, without risk to the consumer, if, in connection with the suggested carry-over arrangement (paragraph 48), a tolerance of 50 p.p.m. were provided for the presence of sulphur dioxide in foods containing one or more Scheduled ingredients allowed to contain sulphur dioxide. In this way, provided the analyst found the sulphur dioxide content of the food to be below 50 p.p.m. it would not be necessary for him to determine the proportion in which the various Scheduled ingredients were present. The provision should not apply to other permitted preservatives, which are not so widely used, nor to Scheduled foods or foods not permitted to contain sulphur dioxide.

56. **Labelling of Foods containing Preservative.** The special labelling requirements for certain Scheduled foods (see paragraph 8) derive from the views expressed by the 1924 Committee that the public had a right to know whether or not food contained a chemical preservative and that the presence of preservative should be declared in a prescribed manner, except where it might be difficult to enforce or result in undue harm to the industry without compensating advantage to consumers.*

57. The requirement laid down in the Regulations, viz., that the seller must either display a notice to the effect that the food contains preservative or label the food with a specially printed declaration "This .... contains preservative", was drawn up before there was any general control of food labelling. Under the Labelling of Food Orders which have been introduced since the Regulations were made, the labels of many pre-packed foods are required to bear a declaration of all ingredients (including any added preservative). It is clear therefore that the appropriateness of any special declaration of the presence of preservative needs to be reviewed. It could be argued that special labelling requirements are no longer necessary, but there may be foods not subject to general labelling requirements which should nevertheless carry a declaration of the presence of preservative, either by label or display notice. It can also be argued that even where ingredients are declared, special attention should be drawn to the presence of preservative. The County Councils Association represented to us that regulations should ensure that the inclusion of a preservative in prepared foods is always indicated on labels.

58. In our view, it would be more appropriate to consider the points made in the preceding paragraph in the light of a general consideration of food labelling which would also take account of the use of other food additives. We therefore

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*Paragraphs 163-165 of the Report of the Departmental Committee, 1924.

propose that the provisions of the Regulations dealing with the labelling of foods containing preservatives should be considered when the Labelling of Food Order is reviewed; there would appear to be no difficulty in retaining the present provisions during the interim period.

59. **Labelling of Preservatives.** Similarly, we consider that the provisions of the Second Schedule of the Preservatives Regulations dealing with the labelling of articles sold as preservatives should be considered in the context of a review of the Labelling of Food Order. In the meantime, the existing provisions should be retained, with minor modifications to allow for the sale of preparations containing more than one permitted preservative where these are to be allowed in admixture under our recommendations.

PART III: CONSIDERATION OF THE PROPERTIES OF CHEMICAL PRESERVATIVES AND THEIR POSSIBLE EFFECTS ON HEALTH

60. The representations we have received call not only for the continued or extended use of the preservatives at present permitted but for many other substances to be allowed in foods. The efficacy of some of these substances as food preservatives has only become apparent in recent years. One new class of preservative, antibiotics, raises special issues and an Antibiotics Panel was set up to advise on the medical aspects. This is further referred to in paragraphs 147–149 below.

61. In accordance with our former practice, the Pharmacology Panel made an appraisal of the possible hazards to health associated with the use in food of preservatives, other than antibiotics, on the basis of data submitted or otherwise available to them on the biological effects of the chemicals and the actual or proposed food uses. The Panel review of the main features of the metabolism, pharmacology and toxicity of the substances examined is given in the following paragraphs.

62. References to works cited in this Part of the report, as indicated by the small superior figures, are given in Appendix II.

63. Because the available pharmacological evidence is only too often incomplete, it is difficult to assess potential health hazards with the precision that would exclude controversy. The substances under review vary considerably in respect of their properties as anti-microbial agents, their physiological action and toxicity, the foods in which they are likely to be used and the amount in which they may be safely tolerated. In each instance the object must be to ensure that the quantity of the substance ingested is substantially less than that expected to produce any adverse effect.

64. For this purpose, it is essential to know the mode of action of the substance, its route and speed of elimination from the system, the organs likely to be affected and their power of recovery. Rarely can controlled experiments be performed on human beings and usually reliance has to be placed on tests with experimental animals. In animal experiments it is usual to employ healthy animals of known history which are well fed and housed under ideal conditions, and the difficulties of arriving at a safe daily intake for human beings from such data are well known.

65. The generally accepted assumption is that man will be at least as sensitive to the substance as the most sensitive test animal, but the sustained ingestion by man of an amount proportional to that producing no adverse symptoms in small animals may well give rise to symptoms of a type which would not be registered by experimental animals, e.g., dyspepsia. Since a food additive may be consumed daily throughout life by human beings of all ages and of differing states of well-being, a substantial margin of safety is necessary between the amount which may be ingested by man and the amount, on a comparable body weight basis, which produces no adverse effects in experimental animals. It is sometimes convenient to do this by applying an arbitrary safety factor. In our view, however, the wiser course is to keep the amount of any additive to the minimum necessary for securing the desired effect provided that this is well within the safe daily intake as indicated from the experimental evidence.

A. PRESERVATIVES AT PRESENT PERMITTED BY THE REGULATIONS

66. **Sulphurous acid** may be used as a food preservative in the form of sulphurous acid, sulphur dioxide, or as the sulphites of sodium, potassium, or calcium; for regulatory purposes limits are prescribed in terms of sulphur dioxide. Sulphurous acid inhibits the growth of yeasts, moulds and aerobic bacteria, its anti-microbial action being due to the undissociated acid[1]. Much of the sulphurous acid added to food may disappear on storage or during processing, as for example in the conversion of preserved fruit into jam or crystallised fruit, or on cooking in the home.

67. Sulphites can combine with aldehydes and ketones and with simple sugars containing such groupings. Thus, in foods such as wines, dried fruits, etc., in which these are present, part of the added sulphite may become "fixed". It is also possible that sulphites may enter into combination with other food constituents. The indications are that the toxicity of the additive compounds of sulphites with aldehydes and ketones met with in foods is no greater, and is probably less, than that of free sulphurous acid, since they behave like free sulphurous acid as regards the symptoms they provoke, but the intensity of the action depends on the speed at which they are decomposed and the sulphur dioxide liberated[2].

68. Sulphite preservatives have been in use for a very long time, but they are open to the objection that they could conceal incipient putrefaction by removing the odour of decaying meat and restoring a bright red colour to discoloured portions[3]. Furthermore, because sulphurous acid tends to inactivate vitamin B_1, it is not a desirable preservative for foods which provide a significant proportion of the dietary intake of thiamine. On the other hand, it prevents darkening of pared fruits and vegetables due to enzyme action, and tends to conserve the vitamin C content.

69. After ingestion, sulphurous acid and sulphites are rapidly oxidised and eliminated in the urine as sulphates, a fact which probably accounted for sulphites being grouped with the least harmful of the preservatives dealt with by the 1924 Departmental Committee. In man, a large single dose of sodium sulphite can produce irritation of the stomach and intestine, followed sometimes by vomiting, diarrhoea and circulatory disturbance. Chronic toxicity studies indicate that rats can consume sulphited diets containing about 300 p.p.m. sulphur dioxide for long periods without toxic effects. Most of the deleterious

effects observed at higher dietary levels have been attributed to destruction of vitamins, in particular of thiamine. There are indications that an otherwise innocuous sulphite-containing diet, if stored for some time before use, may produce adverse effects, due possibly in part to the slow formation of some substance more toxic than sulphur dioxide.

70. Fitzhugh *et al*[4] from long term feeding to rats of sulphite-containing diets found that the safe level of intake of sulphur dioxide was about 14 mg./kg./day. While the greater part of the deleterious effects of sulphited diets was attributed to the destruction of vitamins, in particular of thiamine, it was noted that ageing of the sulphite-containing diets caused some adverse effects. Lockett[5] administered sodium metabisulphite to rats in their drinking water and found that the safe level of sulphur dioxide under these conditions was at least six times that found by Fitzhugh *et al.* More work is required to reconcile these findings and we think it desirable that further studies should be undertaken to determine the ingredient or ingredients of the experimental diets which may be concerned.

71. From the foregoing it is clear that careful consideration must be given to any extension of the use of sulphurous acid and sulphites as food preservatives, both as regards the nature of the food to which they are proposed to be added and the level of use. From estimates prepared for us by the Scientific Adviser's Division (Food) of the Ministry of Agriculture, Fisheries and Food, which are summarised in Appendix III, it would appear that the average dietary intake of sulphur dioxide under the present Regulations is likely to be of the order of 15 mg. per person per day and that, even with the extended scope for the use of sulphur dioxide which the modifications recommended in Part IV of the report will provide, it is unlikely to exceed 20 mg. per person per day. This level is within what we would regard as the safe maximum daily intake.

72. **Benzoic acid** or its sodium or potassium salts, are at present permitted only in coffee extracts, pickles and sauces, soft drinks, and in grape juice not intended for use as a beverage.

73. The antimicrobial action of benzoic acid is due to the undissociated acid. The greater the acidity of the medium the smaller is the amount of benzoic acid required to inhibit growth of micro-organisms, and the action is markedly diminished when the pH exceeds 5. Weight for weight benzoic acid is only about half as effective as sulphurous acid and this is reflected in the Regulations, which permit either 350 p.p.m. sulphur dioxide or 600 p.p.m. of benzoic acid in concentrated soft drinks.

74. On metabolism, benzoic acid is readily eliminated in conjugated form in the urine after combination with glycine to form hippuric acid, and in part with glucuronic acid. Most of the ingested benzoic acid is excreted within 9–15 hours.

75. Benzoic acid is not acutely toxic to human beings[6], or to test animals[7,8]. Studies on the administration of diets containing sodium benzoate to adult human beings indicated that less than 0·5 g./day mixed in the diet was harmless[9].

76. Recent tests indicate that a dietary level of 4% of sodium benzoate, corresponding to about 2·5 g./kg./day can be tolerated by rats without producing adverse effects[10].

77. In our opinion the present use of benzoic acid or its sodium or potassium salts, or their extended use in substitution for, or partial replacement of, sulphurous acid in certain foods is not hazardous to health.

78. **Nitrates and nitrites of sodium and potassium.** Nitrates and nitrites differ considerably in toxicity, but as any hazard associated with the presence of nitrates in food is due to their possible conversion to nitrites it is convenient to consider these two salts simultaneously. Nitrates have long been used in the preparation of cured and pickled meats but we have no information of other food uses in this country. A small addition of nitrate is permitted in cheese in Holland and in butter in France. We understand that, while it is used in certain cheeses, butter manufacturers seldom use it.

79. The antimicrobial action of nitrates is of the same order as that of common salt. Nitrites on the other hand have a much more powerful preservative action and can also inactivate certain enzymes.

80. **Nitrates:** Nitrates occur naturally in many foods and relatively large amounts have been reported in certain vegetables [11,12]. On ingestion, nitrates are readily absorbed and are mostly excreted unchanged, but a small part may be converted to nitrite.

81. According to Harper[13] potassium nitrate can be given in moderate doses to human beings for long periods without causing injury. It would seem that the toxic propensity of nitrates depends on the amount and rate of their conversion to nitrites. In certain circumstances appreciable reduction to nitrite can occur in the digestive tract beyond what the elimination mechanism can cope with, and poisoning may then follow. For example, several cases of methaemoglobinaemia in infants have been reported due to well-water with a high content of nitrate being used to prepare the infants' food[14]. Apparently the intestinal flora of the affected infants, by reduction of the nitrate, produced sufficient nitrite to induce methaemoglobinaemia. The consumption of bread in the preparation of which nitrate was used in error for common salt caused poisoning in fifteen male adults, thirteen of whom exhibited all the symptoms of serious methaemoglobinaemia[15].

82. In view of the potential risk from the conversion of nitrate to nitrite, we think that the addition of nitrates to food should be controlled, and limited to the curing of meats.

83. **Nitrites:** Sodium nitrite is readily absorbed from the intestinal tract, and rapidly disappears from the blood stream. About 30–40% of the absorbed nitrite is excreted unchanged in the urine; the fate of the remaining 60–70% is not accurately known. Nitrite can combine with the meat pigment, myoglobin, to form nitrosohaemoglobin and thereby produces the characteristic red colour of pickled meat. It also oxidises blood haemoglobin to methaemoglobin which has no oxygen-carrying properties. The normal reducing systems of the blood can successfully deal with fairly substantial increases in methaemoglobin in the circulating blood within a matter of hours but once the mechanism becomes overtaxed cyanosis occurs, followed by a progressive methaemoglobinaemia, which, if severe, may prove fatal[16].

84. Several cases of mass poisoning have occurred on the Continent, with some fatalities among children, following the consumption of processed meat products[17,18], which led to the German authorities prescribing a limit of 15 mg. nitrite per 100 g. meat. More recently, ten cases of methaemoglobinaemia in young children were reported from New Orleans due to the consumption of Wiener-sausages containing excessive amounts of nitrite[19]. Lehman[19a] has pointed out that the most significant feature in estimating the health hazards of nitrite is the molar ratio between the nitrite utilised and the methaemoglobin

formed. While there is some difference of opinion as to the actual molar ratio involved, it is clear that only a small margin of safety exists between the amount of nitrite that is safe and that which may be dangerous. The margin of safety is even less in the case of children in view of their smaller blood volume.

85. It is our opinion that the amount of nitrite in foods should be kept as low as practicable and restricted to the curing of meats. The limitation of the nitrite content of such products, as consumed, to 200 p.p.m. or less would seem to provide an adequate margin of safety.

86. As already mentioned, accidents have occurred in the past from the use of nitrate in mistake for salt. Even more serious may be the use of nitrite in mistake for nitrate, which could easily arise from the similarity in the names. For these reasons we recommend that additional precautions should apply to nitrite, such as distinctive labelling or its sale to food manufacturers only in a suitably diluted form.

87. **Diphenyl** is an effective anti-mould agent but is not very active against yeasts or bacteria. The only known use of diphenyl as a food preservative is on citrus fruits; its smell and taste are against its more general use. It is usually incorporated in packaging so that the diphenyl gradually volatilises and inhibits the growth of moulds on the surface of the fruits.

88. Tomkins and Isherwood[20] found that the amount of diphenyl taken up by oranges which had been wrapped in papers impregnated with diphenyl depended on the time and temperature of storage. In a consignment of commercially treated oranges they found about 40 p.p.m. in the peel but practically no diphenyl in the pulp. Marmalade, prepared from treated oranges, was found to contain 0·1 p.p.m. diphenyl.

89. Extensive studies of the diphenyl content of treated oranges have been carried out at the Hazleton Laboratories in the U.S.A. The oranges were shipped in fibre board cartons either treated directly with a diphenyl preparation or by the inclusion of a diphenyl-impregnated liner. In most cases the whole fruit contained 20 to 100 p.p.m., the peel 100 to 300 p.p.m., and the pulp or juice not more than 1 p.p.m. of diphenyl.

90. In 1956, the U.S.A. established a tolerance of 110 p.p.m. for residues of diphenyl in or upon grapefruit, lemons and oranges[21].

91. In the dog, rat and rabbit, diphenyl is excreted largely as 4-hydroxydiphenyl, and West[22] found that over 50% of the diphenyl ingested by rats could be accounted for in the urine in the form of its metabolites. When animals have absorbed a sufficient quantity of diphenyl, they enter into a state of intoxication, characterised by increased respiratory rate, loss of appetite and body weight, muscular weakness, and respiratory difficulties which can terminate in coma or death[23]. Newell[24] found no significant differences between monkeys fed amounts of up to 0·1% diphenyl in their diet for a year and control animals. Rats given dietary levels of up to 0·1% diphenyl for three months showed no significant differences from control animals. De Eds[25] investigated the onset and reversibility of kidney damage in rats at dietary levels of up to 0·5% diphenyl. He found there was no kidney damage at 0·25% or below, and the damage at higher levels was reversible in the absence of continued exposure. Chronic toxicity tests in dogs indicated that no adverse effects followed the feeding of up to 25 mg. diphenyl/kg./week for a year[26].

92. On the basis of the fairly comprehensive tests which indicate that no damage is caused to experimental animals at dietary levels of 0·1%, we think the use of diphenyl on citrus fruits is not hazardous to health.

B. PRESERVATIVES NOT AT PRESENT PERMITTED BY THE REGULATIONS

93. **Sorbic acid** is one of the more recently introduced food preservatives. It functions best under acid conditions and is much more effective against yeasts and moulds than against bacteria[27]. Sorbic acid is not an effective inhibitor of the food poisoning organisms, but it does not stimulate their growth[28, 29]. An advantage claimed for sorbic acid as a food preservative is that it acts as a selective growth inhibitor for many yeasts and moulds, without interfering with the growth of beneficial organisms. In cheese, for example, mould growth can be controlled without impeding the maturing action of lactobacilli and other micro-organisms. Sorbic acid is permitted in foods in several countries in amounts ranging from 0·02% to 0·2% by weight.

94. Sorbic acid is of very low toxicity. It is metabolised to water and carbon dioxide in the same way as the natural saturated fatty acid analogue caproic acid. The chronic toxicity of sorbic acid in rats and dogs has been studied by Deuel *et al*[30], who found no abnormalities in growth or in micropathology in animals given a dietary level of about 4% of the acid or its sodium salt for three months. Indeed, the findings seem to indicate that sorbic acid is utilisable by the animal organism as a source of energy.

95. We are of the opinion that the use of sorbic acid or its sodium salt as a preservative in some foods would not be hazardous to health.

96. **p-Hydroxybenzoic acid esters.** The substances which we have been asked to consider are the methyl-, ethyl-, propyl-, and butyl- esters and their sodium salts. The p-hydroxybenzoates were introduced as preservatives about 1926. According to Sabalitschka and Mard[31] it is only the esters of p-hydroxybenzoic acid and their sodium salts which are of value as preservatives, the free acid being of little use in practical concentrations. This is the converse of the case with sodium benzoate, which in permitted quantities has no preservative value unless the medium is sufficiently acid for free benzoic acid to be liberated. The antimicrobial activity of the p-hydroxybenzoates increases with the length of the alkyl chain of the alcohol moiety up to the amyl ester. Some mixtures of these esters show greater activity than would be expected on the basis of their separate action[32].

97. The esters of p-hydroxybenzoic acid are permitted as food preservatives in several European countries, but they are not included in the Canadian list of permitted preservatives. The quantities usually required for food preservation vary from 500 to 1,200 p.p.m. according to the foodstuff.

98. The methyl-, ethyl-, and propyl-p-hydroxybenzoates are rapidly hydrolysed when given orally or by intravenous injection and excreted in the urine mostly as the free acid or conjugated with sulphuric or glucuronic acid. Only traces of the unchanged esters appear in the urine. In dogs the excretion is almost complete within 48 hours. With the butyl-p-hydroxybenzoate the hydrolysis is much less efficient and only about 40% of the amount administered can be accounted for in the urine[33]. The same course of metabolism appears to hold for man[34].

99. These esters are more toxic when given intraperitonally than by the oral route, probably because of enhanced absorption[33]. All the esters, but not the free acid, can produce a degree of paralysis from which the animals recover prior to death.

100. Extended studies done by Matthews *et al*[33] showed that 2% of the methyl- or propyl-ester in the diet had no adverse effect on rats, but 8% caused inhibition of growth with no toxic symptoms or deaths. With the butyl-ester the 8% level of feeding led to the death of all the male animals.

101. Dogs can tolerate 1 g./kg. of the methyl- or propyl-ester daily for a year or more without toxic effects, and 96–100% of the ester administered daily was excreted in the urine, chiefly as conjugated end products. This and plasma studies furnish strong evidence of lack of cumulation of either the methyl- or propyl-ester at this level of administration[33].

102. We consider that the evidence in respect of the methyl- and propyl-p-hydroxybenzoates indicates that they are no more toxic than benzoic acid. Several representations have been made for these esters to be permitted as alternatives to benzoic acid. Apart from the proposed use in tomato pulp (paragraph 163) there is as yet insufficient evidence to indicate the foods in which they might be more suitable than benzoic acid, and precisely what limits might be appropriate. We therefore recommend that, for the time being, the use of methyl- or propyl-p-hydroxybenzoates or their sodium salts should be permitted as an alternative to benzoic acid in those foods, and only those foods, allowed to contain benzoic acid (but not other preservatives) and that the limits set for benzoic acid should also apply to the methyl- and propyl-p-hydroxybenzoates.

103. The experimental data for the ethyl- and butyl-esters is not so complete or favourable and in our opinion these two esters should not be permitted in foods.

104. **Dehydroacetic acid** (DHA) and its sodium salt (DHA-S) are good anti-mould agents and have been proposed as food preservatives in amounts varying from 0·02 to 0·5%[35], but do not appear to have been officially accepted as food preservatives in any country; on the contrary, the U.S. Food and Drug Administration regard DHA as a deleterious substance[36].

105. Acute oral toxicity data indicate that mice can tolerate more than rats, and rats more than dogs[37,38,39]. Symptoms of acute toxicity relate almost exclusively to the central nervous system. According to Woods *et al*[40], dehydroacetic acid is rapidly and apparently completely absorbed following oral administration to man, monkey, dog, and the rat. In dogs, DHA becomes bound to the plasma proteins and can be detected in the plasma three or more days after giving a single dose of 80 mg./kg., and appears in the urine, bile, milk, spinal fluid, and the foetal plasma and tissue. Shideman *et al*[41] considers that manifestation of toxicity results largely, if not exclusively, from a specific type of chemical or physiochemical action involving interference with oxidative or other enzymic mechanisms which proceed by way of the Krebs cycle. The rate of detoxication is relatively slow and, in view of the sharp line which exists between the level of intake tolerated without symptoms of toxicity and the level which will result in signs of cumulative toxicity, apparently proceeds at a fairly uniform and unchangeable rate in each animal species. Prolonged administration does not appear to alter the rate of detoxication since no acquired tolerance can be demonstrated.

106. In chronic toxicity studies Spencer *et al*[38] found no adverse effects in rats fed for two years on a diet containing 0·1% DHA, or in monkeys given 0·1 g./kg./day for a year. Seevers *et al*[39] found that the maximum tolerated dose for the dog was defined sharply at 50 mg./kg./day, and that the daily oral administration of 60 mg./kg. led to the slow development of an uncompensated metabolic acidosis. Other data presented to us indicated that the safe daily dose for oral administration to mice was 10 mg./mouse or 500 mg./kg./day. Twice this dose resulted in loss of appetite, retardation of growth and occasional deaths. When mice were fed a bread diet made from flour containing 25 times the proposed level of use, growth was inhibited and there was a persistent loss of appetite[37].

107. The available pharmacological evidence tends to be contradictory but indicates that the margin between the possible toxic level and the amounts likely to be used commercially is too small to justify the use of DHA or its sodium salt as a food preservative.

108. **Sodium diacetate** is a loose, equimolecular compound of acetic acid and sodium acetate, and can be prepared by half neutralising acetic acid with sodium bicarbonate. Acetic acid, but not its salts, is exempted by definition from being regarded as a preservative.

109. Sodium diacetate retards the growth of bacteria and to a less extent that of yeasts and moulds; the growth of rope bacteria in bread is inhibited by 0·1% (flour weight). Calcium acetate at 0·3–0·5% (flour weight) acts similarly, but normal sodium acetate is stated to have no such inhibitory action[42]. Sodium diacetate on the other hand appears to enhance the antimicrobial action of acetic acid, being distinctly effective against moulds. This action is probably due to the buffering of the acetic acid by the acetate ion.

110. No information has been submitted on the toxicity of this substance, but in view of its chemical composition we see no reason to expect that the use of sodium diacetate to retard the growth of moulds and rope bacteria would be hazardous to health.

111. **Ethyl-p-nitrobenzoate** is claimed to have a powerful action against moulds, yeasts and bacteria. It has been proposed as an antimould agent for incorporation into the coating of cheeses and wax wrappings (5–8%). Information has been given us that the amount remaining in the whole cheese after surface treatment with a 5% solution is about 8 p.p.m. and that it is located mostly in the crust and outer 10 mm. layer.

112. Abramson[43] carried out some short term feeding tests on rats. There was a significant decrease in weight gain in the animals on diets containing 0·5% and many of the rats on diets containing 2% died during the experiment. At autopsy the animals of both groups showed pronounced enlargement of the spleen. The erythrocyte count and the haemoglobin level decreased with increase in dosage of the test substance. From examinations of the blood and the bone marrow the author concluded that ethyl-p-nitrobenzoate markedly affects blood formation.

113. Miller[44] showed that the action of sodium-p-nitrobenzoate in preventing the growth of certain test organisms was inhibited by p-aminobenzoic acid and folic acid. He thought that the observed effect of ethyl-p-nitrobenzoate on blood formation may be related to this antivitamin effect.

114. The limited data available indicate that ethyl-p-nitrobenzoate has some depressant effect on the bone marrow and the formation of the red and white

cells of the blood and that it exercises its bacteriostatic effect as an antivitamin. For these reasons we consider that ethyl-p-nitrobenzoate is unsuitable as a food preservative.

115. **Ethylenediamine tetra-acetic acid** (EDTA), forms a series of mono-, di-, tri-, and tetravalent sodium salts, the solubility of which increases with the degree of neutralisation. The most important property of EDTA and its salts is the ability to form stable complexes with metals. These complexes are soluble in water and do not give any of the characteristic reactions for the metals, indicating that the metallic element is present as part of a complex anion. EDTA and its salts have been proposed for use in foods to sequester traces of metals which may be responsible for discoloration, turbidity, oxidative changes and off-flavours. EDTA is also capable of inhibiting the growth of some bacterial species, presumably by depriving them of essential mineral nutrients or by blocking enzymatic reactions. The maximum concentration for use in foods is given as 500 p.p.m.

116. Orally EDTA is not acutely toxic[45]. It is much more toxic when given intravenously, the toxicity depending on the rate of injection[46]. On injection, the calcium complex is considerably less toxic than EDTA[47].

117. Metabolism studies in human beings by Foreman and Trujells[48] indicated that EDTA passes through the body unchanged. All the dose could be accounted for in the urine 24 hours after parenteral administration.

118. The life time feeding to rats of diets containing up to 2% of the disodium salt had no significant effect on the general health and well-being of the animals. When the dietary level was raised to 5% the rats suffered from chronic diarrhoea, grew more slowly and were smaller at maturity[46].

119. Spencer *et al*[49] found that the slow intravenous infusion of the disodium or the disodium-calcium salt resulted in excess urinary, but not faecal, excretion of calcium. It caused no lowering of the serum calcium levels in man. The maintenance of serum calcium levels, and the concomitant excess urinary calcium suggest that any decrease of ionised serum calcium by the disodium salt is corrected by prompt replenishment from the skeletal deposits. This agent, therefore, can cause demineralisation of the bones, the extent and rate of which depends on the quantity of the chelating agent and on the speed of its infusion rather than on the state of the skeletal system.

120. Zipkin[50] found that the addition of 0·5% EDTA to a caries-producing diet appeared to promote caries to a marked degree. Concomitantly, the hematocrit value was lowered, and almost complete inhibition of incisor pigmentation was observed.

121. Since the use of EDTA or its salts might reduce the amounts of available calcium and of essential trace elements present in the diet, we would not approve the use of these substances in foods.

122. **o-Phenylphenol** and its sodium derivative are effective bactericides and fungicides, the growth of some common fungi being inhibited by 80 p.p.m. or less. o-Phenylphenol or its sodium salt is used in some countries to combat the growth of mould on fruits during the time between harvesting and consumption and legal tolerances for some fruits have been established in Canada and the U.S.A. Mould growth on citrus fruits can be suppressed by dipping the fruit for up to 3 minutes in a dilute aqueous solution of the sodium salt. This treatment is stated to give in practice a residue of about 60 p.p.m. on the whole fruit.

The sodium salt is gradually converted into the free phenol by the carbon dioxide of the atmosphere.

123. With non-citrus fruits o-phenylphenol is used in the form of a dilute alkaline solution as a dip or spray. With some fruits, but not all, it appears necessary to rinse the treated fruit with water to avoid damage to the skin. It would seem that most of the residue remains on the outside of the fruit, which in the case of fruits like melon and pineapple is not eaten.

124. o-Phenylphenol may be used in the form of impregnated wraps but owing to its lower volatility is probably not so effective as diphenyl when used in this way. Tomkins and Isherwood[51] found that the quantities taken up by oranges, which had been wrapped in papers impregnated with o-phenylphenol, depended not only on the amount in the wraps, but on the variety of the fruit and the temperature and time of storage. Examples of the amounts which may be taken up by the peel and pulp of oranges are given as 5·7–17·4 mg., and 0–0·04 mg. per orange respectively. Marmalade made from treated oranges was found to contain 4·5 p.p.m. o-phenylphenol. This is considerably more than was found in a similar experiment using diphenyl treated oranges where the finished marmalade contained only 0·1 p.p.m.

125. The acute toxicity of o-phenylphenol is similar to that of diphenyl[52,53]. The picture of acute intoxication is one of general depression with death through respiratory failure. Sub-lethal doses usually produced no obvious signs of poisoning.

126. Macintosh[52] found no adverse effects in young rats fed 200 mg. o-phenylphenol/kg./day for a month. Hodge *et al*[53] found that rats could be maintained on a diet containing 0·2% o-phenylphenol without any adverse effects, and there was little evidence of storage in any organ. Dogs tolerated daily doses of up to 0·5 g/kg. for a year and maintained their body weights and were in excellent condition throughout the experiment. Histopathological studies of the various organs showed no evidence of specific tissue damage.

127. The toxicological tests which have been carried out indicate that o-phenylphenol is of a low order of toxicity. We would see no objection to o-phenylphenol or its sodium salt being permitted for the treatment of citrus fruit. Nor, having regard to the amount of o-phenylphenol likely to be ingested, would the treatment of apples and pears (or of certain other fruits which are normally eaten only on occasion and are peeled before consumption) appear likely to present a health hazard. Any residues should, however, be kept to the lowest possible amounts consistent with good commercial practice. We consider it would be undesirable to establish a higher limit than 10 p.p.m. for apples and pears, or to prescribe residue tolerances for the generality of fruits which may be eaten without peeling.

128. **Vanillic acid esters** may be regarded as methoxy derivatives of the p-hydroxybenzoic acid esters and it was this structural relationship which led to the investigation of the vanillic acid esters as preservatives. Pearl and McCoy[5] found that methyl-, ethyl-, propyl- and butyl-vanillates were especially effective against spore-forming, heat resistant bacteria and moulds. In general the antimicrobial activity increases with the molecular weight of the alcohol moiety. Experimentally 0·1% has been shown to retard mould growth in certain foods, but we have no information that the vanillates are permitted in any country as food preservatives.

129. Christie *et al*[55] found that ethyl vanillate had a cumulative effect and that the margin between the therapeutic and toxic dose was only 20–30%.

130. Pearl and McCoy[54] state that toxicity tests have been conducted at the Kettering Laboratory, University of Cincinnati but we have been unable to obtain an account of this work.

131. The available pharmacological data are inadequate for a reliable assessment of the toxicity of the vanillic acid esters to be made, and we therefore cannot approve their use in food.

132. **Hydrogen peroxide.** The use of a solution of hydrogen peroxide has been advocated as a food preservative. The antimicrobial property of hydrogen peroxide depends on its oxidising action on the constituents of bacterial protoplasm. While it has the advantage that in contact with organic matter it readily decomposes into water and oxygen, this evanescent property can also severely limit its use as a practical food preservative.

133. Many investigations[56] have been conducted on the preservation of milk by hydrogen peroxide. The addition of 0·1% to milk immediately after it has been drawn destroys pathogenic organisms, reduces by about 95% the bacterial count and prevents for some days the development of acidity when kept at room temperature. If added some time after the milk has been drawn, its action is merely bacteriostatic. As little as 100 p.p.m. will preserve raw milk for 32 to 82 hours at a temperature of 30°C. If the milk is first pasteurised, the preservative action is extended to 120–168 hours. It has an adverse effect on the enzymes, catalase and phosphatase, the content of which is significantly reduced. It also destroys vitamin C, methionine and tryptophan[57].

134. No information is available to us of the nature of the reaction products of hydrogen peroxide with methionine and trytophan. We are unaware of any experimental investigations into the effect of hydrogen peroxide on food constituents, and are of the opinion that it should not be allowed in foods before it has been subjected to adequate toxicological investigation.

135. **Nitrous oxide** gas is employed in some countries either alone or mixed with carbon dioxide, for the production of whipped cream. Bart[58] found that dry nitrous oxide applied under pressure to bacteria had no bactericidal action, but if applied in a moist condition under high pressures of 20–50 atmospheres it had a marked bactericidal action. On the basis of Bart's observations, Potterat and Hogl[59] formed the opinion that at the pressures obtaining in the manufacture of whipped cream no bacteriostatic action could be expected. They estimated that if 400–800 ml. of whipped cream were consumed in a short time the amount of nitrous oxide which might be ingested would be 300–600 ml., or one-tenth to one-fifth of the smallest concentration that Davidson[60] found to exert any anaesthetic effect.

136. No adverse effect was observed in a dog fed cream treated with nitrous oxide in quantities which, calculated for a man weighing 60 kilo, would entail the ingestion of 2·7 kilo of cream. Fully grown mice fed for 15 days exclusively with nitrous oxide treated cream showed no differences from control animals fed with untreated cream. The consumption of daily quantities of about 100 g. of cream treated with nitrous oxide caused no disturbances in human beings.

137. The amount of nitrous oxide likely to be consumed in whipped cream is so far below that which leads to anaesthesia, the only possible toxic effect, that the proposed use does not in our view present a health hazard.

138. **Propionic acid** or its calcium or sodium salts have been found to be effective in controlling rope and mould growth in bread. Double salts of propionic acid and sodium propionate have also been developed. Propionic acid is a saturated fatty acid and is produced naturally by fermentation in the manufacture of Swiss cheese, which may contain about 1%. In tests with a number of micro-organisms Heseltine[61] showed that the bacteriostatic and fungistatic activity of sodium propionate was greater in acid than in neutral or slightly alkaline solution, which suggests that the antimicrobial action is due to the undissociated acid.

139. Propionic acid is a constituent of human body fluids and is probably produced by the breakdown of higher fatty acids; it is found in sweat as the free acid or its salts[62]. It is absorbed fairly readily, and the greater part of that ingested is probably oxidised in the tissues to carbonate.

140. Harshbarger[63] found that the growth rate of rats, fed diets containing up to 3·0% of sodium or calcium propionate, was not affected.

141. It seems clear that propionic acid is relatively non-toxic and would be metabolised in the same way as acetic acid. We therefore consider that propionic acid and its sodium and calcium salts may safely be used as food additives.

142. **Boric acid** or its sodium salt, borax, was a commonly used food preservative until its use was prohibited by the 1925 Preservative Regulations. As a temporary measure during World War II borax was allowed in bacon and margarine but this relaxation of the Regulations was withdrawn at the time of decontrol.

143. Boron is an essential trace element in plants and small quantities are present in most foods of vegetable origin[64]. Boric acid is only a weak germicide with apparently a selective action on different bacteria[65]. The acute lethal dose of boric acid for most species of animals is relatively large[66]. It is readily absorbed from the gastrointestinal tract and is excreted, primarily by the kidney, more slowly than it is absorbed, so that it accumulates in the system.

144. The 1924 Departmental Committee grouped boron preservatives with the less desirable substances on evidence which not only dealt with the potential cumulative properties but also with the fact that their use could mask incipient putrefaction and lead to the consumption of unwholesome food.

145. Following the reports of fatalities among infants due to boric acid, coupled with the fact that it is therapeutically so ineffective, there have been strong recommendations in the medical literature that boric acid should be eliminated from Pharmacopoeias[67].

146. We endorse the view expressed by the 1924 Departmental Committee that boric acid and borax should not be permitted as food preservatives.

147. **Antibiotics** are chemical substances, prepared from micro-organisms, which interfere with the metabolic processes of other organisms and retard or prevent their growth. The discovery of penicillin by Fleming in 1929, and its successful medical application, stimulated the search for other antibiotics and several thousands have by now been prepared, though only a few are of practical use. The use of antibiotics as food preservatives is a recent development. The antibiotics which have been submitted to us for consideration are **chlortetracycline** (aureomycin) and **oxytetracycline** (terramycin) for eviscerated poultry, fish and whales, and **nisin** for cheeses and certain canned foods.

148. In view of the widespread and important use of antibiotics in medicine, and the possibility that their use as food preservatives might adversely affect

their value when used therapeutically, or have other undesirable consequences, it was decided to appoint a special Panel of experts to advise on the health aspects of the proposals submitted to us for the use of antibiotics in foods. The report of this Panel, which we endorse, is given in Appendix IV.

149. The conclusions of the Panel as reported in Appendix IV are as follows:

Chlortetracycline and oxytetracycline:

(i) If eviscerated poultry, containing not more than 7 p.p.m. in any part of the raw bird, of chlortetracycline or oxytetracycline, are kept from the time of treatment to the time of cooking at temperatures of 3°C. or less, there is on the basis of available evidence, no hazard to the consumer, but the present evidence is insufficient to assess what degree of hazard from food poisoning may exist if the temperature is not thus maintained throughout.

(ii) The possibility of medical disadvantages attending the use of tetracyclines on fish, has not yet been wholly excluded.

(iii) Whale meat extract and whale oil products derived from tetracycline-treated whales do not present a hazard if the processing is of a nature by which all the antibiotic is destroyed.

Nisin:

(i) No hazard exists in the use of nisin in cheeses.

(ii) No hazard exists in the use of nisin where the product needs in any case to be processed under conditions which ensure the destruction of all mesophiles.

(iii) No hazard exists in the use of nisin in products such as canned fruit, provided the pH of the product is below 4·5.

(iv) The use of nisin in olives may not be free from the hazard of botulism.

(v) The use of nisin on certain meat products such as brawn, ham and sausages, etc. may be associated with the hazard of salmonellae poisoning.

C. IDENTITY, COMPOSITION, PURITY AND DETECTION OF PROPOSED PERMITTED PRESERVATIVES

150. In each section dealing with a preservative which it is proposed should be allowed in specified foods, we have indicated the chemical identity of the compound or compounds to which our opinion as regards freedom from health hazard relates. We recommend that these, and only these, compounds should be specified in revised regulations.

151. Substances sold as preservatives must be of a purity consistent with their use in food and, as with other food additives with which we have dealt, we consider that specifications of purity should be drawn up for each permitted preservative.

152. Methods of analysis are available for the determination of the individual preservatives in food. Our recommendations will provide greater scope for the presence of more than one preservative in a food, and the accurate determination of each may present some problems for the analyst. We do not consider, however, that there should be any great difficulty in obtaining sufficient chemical evidence to support enforcement proceedings.

PART IV: CONSIDERATION OF THE CASE FOR PERMITTING PRESERVATIVE IN INDIVIDUAL FOODS

A. FOODS AT PRESENT PERMITTED TO CONTAIN PRESERVATIVE

Sausages (Item 1)*

153. The 1924 Departmental Committee regarded the addition of a preservative to sausages as undesirable and expressed the view that "improvements in methods of preparation, storage and distribution should eventually enable preservative in sausages to be dispensed with". As a concession to manufacturers distributing over a wide area, the Regulations allowed up to 450 p.p.m. of sulphur dioxide in sausages and sausage meat. We have received no representations in favour of a change in the present provision. Such evidence as we have indicates that it is still the practice for larger manufacturers to incorporate preservative, though many sausages are sold without added preservative. As indicated earlier (paragraph 19), there is no evidence that the presence of sulphur dioxide in sausages favours the growth of pathogenic organisms. The combination of meat with moist cereal filler is conducive to rapid souring and a prohibition on the use of preservative would present difficulties to manufacturers for which there would appear to be no commensurate gain to the consumer. Thus while we would not wish to see any extension in the use of sulphur dioxide for preserving meat products, we would not object to its continued use in sausages and sausage meat up to the existing limit of 450 p.p.m.

Butchers' Minced Meat (Item 18a)

154. Under the existing Scottish Regulations the addition of 450 p.p.m. of sulphur dioxide to butchers' minced meat is allowed, but only during the summer months (i.e. June, July, August and September). There is no corresponding provision in the Regulations relating to England and Wales and to Northern Ireland.

155. There is little doubt that the use of sulphur dioxide in minced meat is open to abuse. It can serve to offset unhygienic methods of handling and transport and to facilitate the disposal of meat of inferior quality. On the other hand, the Scottish Federation of Meat Traders' Associations has represented to us that its use during the summer months is essential to enable them to carry on business. Minced meat, which is said to be more widely consumed in Scotland than elsewhere, has to be delivered to widely scattered areas and without preservative it is said to discolour quickly and to develop a bad odour at the end of a long delivery round in a closed van. For those who cannot overcome these difficulties through the use of refrigerated transport or other means, we see no alternative to allowing the continued use of sulphur dioxide, but we would hope that it will be found possible to dispense with its use in minced meat altogether before very long.

156. We have received representations from Northern Ireland that the Scottish concession should be extended to that country, and from Scotland that the present concession should be extended to the remainder of the year, but we do not think a sufficient case has been made out for either.

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*In Part I of the First Schedule of the Preservatives Regulations.

Fruit and Fruit Pulp for manufacturing purposes (Item 2)

157. The regulations at present allow 1,500 p.p.m. of sulphur dioxide in fruit and fruit pulp other than cherries (allowed 3,000 p.p.m.) and strawberries and raspberries (allowed 2,000 p.p.m.) provided the fruit or pulp is for conversion into jam or crystallised, glace or cured fruit.

158. The need to sulphite fruit for subsequent use in food manufacture after the short harvest period, and also fruit pulp, which is imported in bulk, is generally recognised. The purpose of the present limits must be to ensure that manufacturers and wholesalers are not supplied with pulp which is so heavily sulphited that it is difficult, if not impossible, to remove sufficient to ensure that the jam or other final product does not contain an excessive amount. The consumer is protected primarily by the limits set for the sulphur dioxide content of these foods and by the limit of 350 p.p.m. for other fruit and fruit pulp (Item 7a).

159. The provision in the present Regulations which allows a Scheduled food to contain sulphur dioxide in any quantity provided it can be shown that it is intended to be so treated before it is sold by retail as to comply with the limits in the Schedule (Regulation 4(I)(iii)(b)) does not extend to fruit and fruit pulp. Important sections of the food industry have represented to us that the exclusion of fruit and fruit pulp from the provision is anomalous. While specially high limits are allowed for fruit and fruit pulp for conversion into jam or crystallised fruit, fruit pulp which is to be used for other purposes must strictly speaking contain no more than 350 p.p.m. of sulphur dioxide even when it is imported.

160. In practice, it is not possible to enforce the distinction between pulp for making jam or crystallised fruit and pulp in bulk for use by other sections of the food industry. Moreover, Port Health Authorities are often prepared to allow the import of pulp containing an excessive amount of sulphur dioxide so long as they are satisfied that it is being consigned to a processor who will use it in such a way that ultimately the Regulations will be complied with. This is particularly the case with apricot pulp which has been imported mainly from Yugoslavia and Italy. Where it is cold pulped, the amount of sulphur dioxide required exceeds the 1,500 p.p.m. at present permitted and the trade has represented that apricot pulp should be allowed to contain 2,000 p.p.m., as in the case of strawberry and raspberry which are also cold pulped. It has been suggested that this limit should also apply to blackberries and loganberries. We would see no difficulty in extending the limit of 2,000 p.p.m. to these other fruits so long as the limits which affect the food as sold to the consumer are maintained. Indeed, in the interests of simplification it would seem sufficient to have a single limit of 3,000 p.p.m. for all fruit and fruit pulp for manufacturing purposes.

161. So far as the application of the limit is concerned, the solution suggested by the trade is to retain the present Item 2 in the Schedule but to omit the words "other than fruit and fruit pulp" from Regulation 4(I)(iii)(b). This would have the effect of allowing an unlimited amount of sulphur dioxide in all fruit and fruit pulp, including that destined for uses other than jam and crystallised fruit, whereas the limit for these latter uses is clearly intended as a concession. We see no strong argument for differentiating between the various uses to which the pulp is put, always provided that before it is sold by retail it has been suitably processed to bring the sulphur dioxide content down to the limit set for the end product. On the other hand, if no limit is fixed for the preservative content when the pulp is imported or sold for manufacturing purposes, the manufacturer may find it difficult to ensure that his products ultimately conform to the limits, and

with the widespread use of pulp in a variety of foods the consumer might in practice be insufficiently protected.

162. We therefore recommend that there should be an overall limit, from which there would be no exemption, of 3,000 p.p.m. for the sulphur dioxide content of fruit pulp (including peel, but excluding tomato pulp) sold for manufacturing purposes.

163. The Tomato and Cucumber Marketing Board supports an application for the use of para-hydroxybenzoic acid esters as an alternative to sulphur dioxide in the preservation of tomato pulp. The use of up to 350 p.p.m. of sulphur dioxide is permitted at present but this is stated to be insufficient to keep the pulp in a stable condition. Manufacturers of tomato juice, soup and chutneys therefore rely upon imported canned tomatoes, with the result that a substantial market for home grown tomatoes for processing is lost. Our previous recommendation would allow the use of greater quantities of sulphur dioxide but it is pointed out that the amounts which would be sufficient for adequate protection (about 1,500 p.p.m.) could not be removed during the subsequent processing without heating the pulp to a temperature which would adversely affect the flavour of the product. It is therefore proposed that, as in several Continental countries, the use of approximately 900 p.p.m. of an alkyl para-hydroxybenzoate should be permitted in tomato pulp. We consider that this proposal should be accepted, and recommend that provision should be made for tomato pulp sold for manufacturing purposes to contain not more than 900 p.p.m. of methyl or propyl para-hydroxybenzoate.

Dried Fruit (Item 3)]

164. We have received no representations about the existing provision for dried apricots, peaches, nectarines, apples and pears and see no reason to recommend any change in the present limit of 2,000 p.p.m. of sulphur dioxide. These fruits are invariably cooked before they are eaten in any quantity, and a considerable proportion of the sulphur dioxide will be driven off.*

165. With regard to the limit of 750 p.p.m. of sulphur dioxide in raisins and sultanas, the United States Raisin Administrative Committee has submitted evidence to us in favour of an increase in the amount permitted in Golden Thompson Seedless raisins. At present, these are exported to this country in conformity with the limit of 750 p.p.m., but this involves the adoption of special techniques since larger amounts of sulphur dioxide are permitted in the United States itself and in other countries to which Californian raisins are exported. Production specially for the United Kingdom market increases costs and involves marketing risks in trying to assess before harvesting the likely market in this country. It is claimed that sulphur dioxide when combined with the sugars in dried fruits is in a harmless form; that the effect of treating the fruit with sulphur dioxide is to retain its nutritive value and that conforming to the present United Kingdom limit adversely affects the appearance and keeping quality of the fruit. The Committee ask for a modification in the limit "at least to the extent of permitting the same range of sulphur content that is now allowed .... for other dried fruits", i.e., 2,000 p.p.m.

166. We accept that combination with the sugars in the dried fruit is likely to make the sulphur dioxide relatively less toxic and that when sultanas are used

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*Experiments by the Scientific Adviser's Division (Food) of the Ministry of Agriculture, Fisheries and Food indicated that, after cooking, dried apricots, peaches and pears contained from 45-70% of the sulphur dioxide present before cooking.

in cooking a considerable proportion of the free sulphur dioxide will be driven off. Raisins and sultanas are sold in confectionery form for direct consumption but they are not normally eaten raw except in comparatively small quantities. It would be impracticable to distinguish for the purpose of regulations between fruit which will be consumed raw and that which will be cooked before consumption.

167. On balance, we are of the opinion that it would be reasonable to allow raisins and sultanas to contain the same amount of sulphur dioxide as other dried fruit and therefore recommend that the limit for raisins and sultanas should be raised to 2,000 p.p.m.

Unfermented Grape-juice products used for sacramental purposes (Item 4)

168. Because these products are kept for long periods after the bottle has been opened, the regulations allow them to contain up to 2,000 p.p.m. of benzoic acid provided they are labelled "contains preservative and is not intended for use as a beverage". The amount consumed is very small and we see no objection to the continuation of this provision.

Concentrated Soft Drinks (Item 5)

169. This Item at present reads: "other non-alcoholic wines, cordials and fruit juices, sweetened or unsweetened". Changes in the pattern of soft drinks production and other developments since the Regulations were made have led to a number of ambiguities and it is clear that the definition of the Item (and Item 14—see below) needs revision to take account of legal rulings and to bring it into line with current practices.

170. In our view, it would be convenient, subject to any changes which may be made as a result of the recent report of the Food Standards Committee,* to base the definition of this item upon the Food Standards (Soft Drinks) Order† which defines and to some extent controls the composition of the various types of soft drinks now being made. The first part of the Item would therefore relate to "soft drinks for consumption after dilution" the words "soft drinks" having the meaning ascribed to them in the Food Standards (Soft Drinks) Order. If this is accepted it remains necessary to clarify the position of fruit juices and drinks known as "glucose beverages" and "non-alcoholic wines".

171. Fruit juices are excluded from the definition of "soft drinks" in the Standards Order and separate provision will therefore need to be made for them if the revised definition of this Item is accepted. We consider that continued permission to use a preservative is necessary and recommend that provision should be made for "fruit juices, sweetened or unsweetened, whether concentrated or not" to be allowed to contain the same amount of preservative as soft drinks for consumption after dilution.

172. Glucose beverages come within the definition of soft drinks (though at present they are, under certain conditions, exempt from the minimum standards laid down) but there is doubt whether they should be allowed the amount of preservative appropriate to a concentrated or a ready-to-drink soft drink. At present the manufacturers contend that their products come within the scope of Item 5 and the amount of benzoic acid used exceeds the limit for Item 14 (120

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*Report of the Food Standards Committee on Soft Drinks, H.M.S.O., 1959.
†S.I. No. 1828 of 1953 as amended by No. 1089 of 1954.

p.p.m. of benzoic acid) though it is less than the amount permitted under Item 5 (600 p.p.m.). It appears that these beverages can be diluted or they can be drunk without dilution. The manufacturers say that the total solids content of these drinks corresponds with that of soft drinks sold for consumption after dilution and that the contents of the bottle are never consumed on one occasion. It is, in their view, necessary for the product to keep satisfactorily for several days or even weeks after opening, and 120 p.p.m. of benzoic acid is insufficient for this purpose. We think there is sufficient force in these arguments to justify making special provision for the preservation of beverages of this kind. The Food Standards Committee recommended that the present exemption of glucose beverages from the Soft Drinks Order should be dropped and that they should be treated as ordinary soft drinks. If this recommendation is accepted, it will not be possible to allow the higher preservative content by reference to the composition of "glucose beverages" at present specified (viz., a content of not less than 23% of "liquid glucose" or 10% of dextrose monohydrate). We therefore suggest that it should be specified that beverages having a carbohydrate content comparable with that normally found in soft drinks for consumption after dilution should rank with such soft drinks for the purposes of the Preservatives Regulations, whether they are normally consumed after or without dilution.

173. Separate reference to "non-alcoholic wine" was omitted from the Food Standards (Soft Drinks) Order because of legal doubt as to whether the description was admissible. In the circumstances, we propose that the reference to "non-alcoholic wine" in the Preservatives Regulations should similarly be avoided. We accept the view of the soft drinks industry that, because of the large amount of sugar present in these beverages, the amount of preservative allowed should be the same as for concentrated soft drinks. The suggestion we have made in the previous paragraph in regard to "glucose beverages" would similarly cover these products.

174. With regard to the amount and type of preservative to be allowed in concentrated soft drinks, we have received representations from the trade that the limit for benzoic acid should be raised from 600 p.p.m. to 800 p.p.m. and that sulphur dioxide and benzoic acid should be allowed in admixture instead of only as alternatives as at present.

175. The trade's contention is that 800 p.p.m. of benzoic acid corresponds more closely to the preservative power of 350 p.p.m. of sulphur dioxide, and that the present limit of 600 p.p.m. is rather too low to be effective. It is pointed out that 0·1% of sodium benzoate (equivalent to approximately 840 p.p.m. of benzoic acid) is permitted in the United States. We would see no objection to increasing the limit for benzoic acid to 800 p.p.m.

176. We have already stated that we see no objection in principle to the use of more than one permitted preservative in a food. In the case of soft drinks, there appears to be a definite advantage in allowing a mixture of sulphur dioxide and benzoic acid to be used. We understand that sulphur dioxide alone in the maximum permitted concentration tends to affect adversely both the flavour and the colour of the product. On the other hand, being volatile, while it has the advantage of gathering in the head space of the bottle and thus preventing mould forming on the surface during storage, it has the disadvantage that once opened much of it is lost. Benzoic acid, on the other hand, is not lost by evaporation or oxidation during storage, but it is an inferior preservative and

has to be used in greater quantity to be effective. Freedom to use both preservatives will enable manufacturers to vary the proportions to obtain the optimum effect.

177. We therefore recommend that soft drinks for consumption after dilution (as defined in the Soft Drinks Order); soft drinks for consumption after or without dilution having a carbohydrate content comparable to that normally found in soft drinks for consumption after dilution; and fruit juices, sweetened or unsweetened, whether concentrated or not, should be allowed to contain not more than 350 p.p.m. of sulphur dioxide or 800 p.p.m. of benzoic acid or a proportionate mixture of the two.

Jam (Item 6)

178. As has already been mentioned (paragraph 9), the limit for the sulphur dioxide content of jam was raised in 1944 from 40 p.p.m. to 100 p.p.m. The Food Manufacturers' Federation wish the high limit to be retained. It is pointed out that even before the war the industry found it difficult to comply with a limit of 40 p.p.m. and changes in manufacturing techniques leading to a reduction in the time to which the sulphited pulp is subjected to boiling temperatures have made it even more difficult to reduce the sulphur dioxide content to 40 p.p.m. The difficulty is particularly acute with blackcurrant jam and results of tests have been submitted indicating that more than half of 24 samples of blackcurrant jam contained over 40 p.p.m., or 15 out of 18 if those made from frozen fruit are excluded.

179. Except in the case of blackcurrant jam, a limit of 100 p.p.m. might seem to be unduly generous since most manufacturers appear to have no difficulty in conforming to a limit of 40 p.p.m. The available evidence suggests that two thirds of the jam on sale contains no more than traces of sulphur dioxide and that only about 10% of samples exceed 40 p.p.m. It would be possible to recommend a special limit for blackcurrant jam and a reversion to the limit of 40 p.p.m. for other jams, but this would in effect impose a more stringent requirement on some jams than, by virtue of the carry-over provision, might apply to other foods made from fruit pulp. While we think all reasonable efforts should be made to keep the sulphur dioxide content of jam and marmalade as low as possible, we do not recommend any change in the present limit of 100 p.p.m.

180. One firm has suggested that cherry preserve should be allowed to contain 150 p.p.m. of sulphur dioxide because under Item 2a cherries for jam making are allowed to contain 3,000 p.p.m. of sulphur dioxide and the retention of sulphur dioxide in the flesh of the fruit makes it difficult to conform to the limit of 100 p.p.m. We cannot accept the argument that because the pulp is allowed to contain a high concentration of preservative, the final product must necessarily be allowed to do so; indeed our proposal for a single limit of 3,000 p.p.m. for all manufacturing pulp presupposes that manufacturers will take whatever steps are necessary to ensure that the finished product conforms to the appropriate limit. We do not think a sufficient case has been made out for a special limit for cherry preserves.

181. We have also received representations about preserves which are sold for special dietetic purposes. It is suggested that because of their low sugar content these products might be held not to come within the existing Item 6. In one

case we have merely been asked to recommend that they should be included with jam and allowed to contain 100 p.p.m. of sulphur dioxide. Another proposal is that they should be permitted to contain 200 p.p.m. of benzoic acid because, it is stated, the products in question contain about half the sugar content of normal preserves and this is insufficient to prevent mould growth. We are reluctant to recommend special provision for such products, but see no objection to their being allowed to contain the same amount of sulphur dioxide as jam.

Crystallised and other cured fruits (Item 7)

182. The scope of the present item, "Crystallised glacé or cured fruit (including candied peel)" is uncertain and we have received a number of representations that the position should be clarified. The first point to which attention is drawn is the absence of a comma between "crystallised" and "glacé". We agree that the provision should be read as applying both to crystallised fruit and to glacé fruit. The term "cured fruit" is open to the objection that it is not sufficiently distinguished from dried fruit (Item 3). Though methods of manufacture vary, the essential difference would seem to be that sugar has been added by one means or another. We have also been asked by the Food Manufacturers' Federation to clarify the position of cut and drained (syruped) peel which, they contend, should be expressly included under this Item because it is similar to, but not the same as, candied peel. We agree that this product should be included. In view of these considerations we recommend that Item 7 be replaced by the following:

(a)] crystallised and glacé fruit;

(b) candied peel and cut and drained (syruped) peel;

(c) syruped fruit.

183. The Australian Senior Trade Commissioner in London has represented to us on behalf of his Government that the present limit of 100 p.p.m. of sulphur dioxide is insufficient to ensure an adequate storage life for sale abroad of Australian products which are sweetened dried fruits having some similarities to crystallised fruit and some to ordinary dried fruit. It is claimed that a sulphur dioxide content of not less than 750 p.p.m. at the time of importation is necessary to maintain good keeping quality, though at the time of consumption it is likely to average 600 p.p.m. before cooking. We are satisfied that genuine glacé fruits with adequate storage life can be prepared with the present limit of 100 p.p.m. and we see no reason for increasing it. The Australian products can, however, in our view be regarded as sweetened dried fruits and described in this way would thus be allowed to contain under the carry-over provision an amount of sulphur dioxide appropriate to the dried fruit constituent. Since the added sugar is stated to be approximately 35% this would permit the products to be adequately preserved.

Other Fruit and Fruit Pulp (Item 7a)

184. Our proposals for dealing with fruit pulp for manufacturing purposes (paragraphs 157 to 162 above) will, if adopted, remove the anomaly that at present pulp for processing other than in making jam or crystallised, glacé and cured fruit can contain only 350 p.p.m. of sulphur dioxide. On the other hand, they make it imperative to retain a provision of this kind which will restrict the preservative content of fruit and fruit pulp and all foods containing them when they are consumed. The limit of 350 p.p.m. will apply to any fruit and

fruit pulp sold by retail and, for purposes of the carry-over provision, to the fruit and fruit pulp constituent of any compounded food containing them.

185. Certain representations for permission to use benzoic acid or a p-hydroxybenzoic acid ester as an alternative to sulphur dioxide can conveniently be dealt with here. The first is in respect of prepared fruit for ice cream. It is stated that prepared fruit which has been preserved with sulphur dioxide imparts an objectionable taste to the ice cream. A similar request is made in respect of cherries used in the manufacture of fruit salad packs. The reason given is that the removal of sulphur dioxide involves considerable expense. A third request relates to the use of up to 800 p.p.m. of benzoic acid in fruit pie fillings. It is stated that a new type of trade is being developed in this country and for export of mixtures of fruit and sugar having a soluble solids content of 32–45%, depending on the type of fruit. The pack is canned and sterilised, but the preservative is required after the can has been opened. It is pointed out that the use of up to 1,000 p.p.m. of benzoic acid is permitted in certain pie fillings in the United States and Canada.

186. We see no need for making special provision for each of these proposed uses in view of the carry-over clause, but we think it would not be unreasonable to allow benzoic acid as an alternative in this Item, as for concentrated soft drinks. Limits of 350 p.p.m. sulphur dioxide or 800 p.p.m. benzoic acid, or appropriate admixture, would substantially meet traders' requirements in all the cases mentioned.

187. The question of a special provision for intermediate sales of foods containing benzoic acid is dealt with in Part II.

Sugar (Item 8)

188. Up to 70 p.p.m. of sulphur dioxide is permitted in "sugar (including solid glucose) and cane syrups". This is in the nature of a carry-over from the production processes and not a means of preserving the sugar. Many kinds of sugar in the form in which they are sold to the public do not contain sulphur dioxide and where any has been found by public analysts the amount is very small. In view of this, it was suggested to us that the present provision should be withdrawn, or the limit reduced. We took this matter up with the sugar refining industry who, after consideration, expressed the view that the limit of 70 p.p.m. should be retained. It was stated that in practice refined brown sugars already approach this limit. We recommend retention of the present limit but suggest that the item should be re-worded as follows:

(a) sugar and sugar syrups;

(b) solid hydrolysed starch.

Prepared Starches (Item 8a)

189. Sulphur dioxide up to 100 p.p.m. is allowed in cornflour (maize starch) and other prepared starches. We have received no representations about the present provision and do not recommend any change.

Corn Syrup (Item 9)

190. Sulphurous acid is used in the manufacture of the products variously known as "corn syrup" or "liquid glucose" to prevent colour formation. The amount at present permitted is 450 p.p.m. Since it is not sold for direct consumption undiluted, we consider this limit is not objectionable.

191. Representations have been made to us that the same provision should be made for a glucose syrup product which is similar to "liquid glucose" but contains more dextrose. We think this is reasonable and therefore recommend that the definition of this Item should be amended to "hydrolysed starch syrups".

Gelatin (Item 10)

192. We have received no representation about the existing provision under which gelatin can contain up to 1,000 p.p.m. sulphur dioxide. We understand that sulphur dioxide is used as a bleaching agent in the manufacturing process and that 1,000 p.p.m. is considered necessary for that purpose, although the article sold by retail normally contains less than half this amount. In the circumstances we have no objection to the present limit being retained.

193. Experiments have been conducted with the addition of nisin to gelatin to inhibit the growth of clostridia but we do not think that under good manufacturing conditions this need be a serious problem for food manufacturers.

Beer (Item 11)

194. The 1924 Departmental Committee recommended that beer should be allowed to contain a small amount of sulphur dioxide not only to allow for carry-over from the cleaning of casks with sulphite solutions but because some light beers contained insufficient hops to preserve the beer for a reasonable period. Beers are therefore allowed to contain 70 p.p.m. of sulphur dioxide.

195. We have received representations that the limit for sulphur dioxide should be raised to 100 p.p.m. and that alternative preservatives to sulphur dioxide should be permitted.

196. The request for an increase in the limit comes from the Brewers' Society on behalf of a few of its members. Several types of beer do not contain a preservative, either because the beer is pasteurised or because the use of sulphur dioxide would impart an unpleasant flavour to the beer. Pasteurisation is liable to damage the flavour and although this can be overcome by suitable processes, these are not generally employed because of the additional manufacturing cost. Where sulphur dioxide is used, the suggestion is that a limit of 70 p.p.m. is unduly onerous, bearing in mind the limitation brought about by the effect on flavour and the fact that other alcoholic beverages are allowed to contain much larger quantities of sulphur dioxide.

197. Against this it must be pointed out that beer already appears to account for quite a substantial proportion of the overall intake of sulphur dioxide and an increase in the permitted amount from 70–100 p.p.m. could have a significant effect on the amount ingested. We have no evidence that restricting the amount of sulphur dioxide to 70 p.p.m. results in substantial spoilage of beer. Indeed, even the lower gravity beers produced during the war apparently kept sufficiently long when only this amount of preservative was permitted, although it is argued that the shelf-life required now is longer than it was under wartime conditions.

198. On balance, we do not think that a sufficiently strong case has been made out to justify an increase in the limit for sulphur dioxide in beer and we recommend that it should remain at 70 p.p.m.

199. The Brewers' Society consider that there is a strong case for allowing alternative preservatives in beer in view of the difficulties of controlling spoilage organisms and the objection to sulphur dioxide on flavour and other grounds. Those put forward are benzoic acid and hydrogen peroxide. The possibility of

using antibiotics is also being explored, but no specific proposals have been made so far. Representations have also been made by one firm that up to 5 p.p.m. of a commercial preservative manufactured in Denmark should be allowed as a substitute for the pasteurisation of beer. This preservative is a glycol ester of bromacetic acid and evidence was submitted of its effectiveness against yeasts.

200. We see some objection on general grounds to allowing alternative preservatives in beer. The amount of benzoic acid necessary would be substantial and permission to use it might lead some manufacturers to switch to it as a cheap alternative to pasteurisation. The use of hydrogen peroxide or a glycol ester of bromacetic acid is not considered desirable on pharmacological grounds even though the amount remaining in the beer would be very small. We do not therefore consider that there is at present a sufficient case for allowing any preservatives other than sulphur dioxide in beer.

Cider (Item 12)

201. Cider is allowed to contain 200 p.p.m. of sulphur dioxide. No representations have been received about this limit and we do not recommend any change, except to make it clear that the provision extends to perry.

Wines (Item 13)

202. We have received very little information about preservatives in wine but it appears that some sulphur dioxide is generally employed to combat secondary fermentation and the development of sourness, and its use is permitted in wine growing countries. Up to 450 p.p.m. of sulphur dioxide is at present allowed.

203. It has been suggested to us by one company that benzoic acid or methyl p-hydroxybenzoate should be permitted in addition to sulphur dioxide as a more effective means of preventing the development of lactobacilli. It is not intended that it should replace sulphur dioxide but supplement it. We have received no indication that the bulk of the wine industry is dissatisfied with the present position and on the evidence supplied to us are unable to recommend any change in the present provision. The limit applies to both imported and British wines.

Sweetened Mineral Waters (Item 14)

204. At present "sweetened mineral waters" may contain either 70 p.p.m. of sulphur dioxide or 120 p.p.m. of benzoic acid. It is clear from paragraph 154 of the Report of the 1924 Departmental Committee that this was originally intended to apply only to carbonated beverages, but other soft drinks, some of which have been developed since 1925, do in fact contain preservative. Many of the considerations regarding definition and suitable limits which are discussed in paragraphs 169 to 177 above are also relevant to ready-to-drink soft drinks; the arguments need therefore not be repeated here. We recommend that the present Item should be replaced by limits of 70 p.p.m. sulphur dioxide or 160 p.p.m. benzoic acid, or appropriate admixture, applying to soft drinks for consumption without dilution, other than those specified in paragraph 177.

Brewed Ginger Beer (Item 15)

205. Brewed ginger beer (allowed to contain 120 p.p.m. benzoic acid) falls within the definition of "soft drinks for consumption without dilution" and, if the above recommendation is accepted, there appears to be no need to make separate provision for it. There seems no reason why the trade should not be

free to preserve this soft drink with sulphur dioxide instead of benzoic acid if they so wish. We recommend that this Item in the Schedule should be deleted.

Coffee Extracts

206. The Regulations allow "coffee extracts" to contain 450 p.p.m. of benzoic acid. Since the Regulations were framed, dry coffee extracts have come on to the market. There is no need for these to contain a preservative; nor need liquid coffee extracts if they contain sufficient sugar. However, the Food Manufacturers' Federation have indicated that they wish this provision to be retained and there is evidence that some liquid coffee extracts are still being preserved with benzoic acid.

207. We see no objection to the present limit of 450 p.p.m. benzoic acid being retained for liquid coffee extracts.

208. It has been pointed out to us that the present definition does not extend to coffee and chicory extracts and that these are sometimes preserved with benzoic acid. We recommend that the Item should refer to "liquid coffee (or coffee and chicory) extracts".

Pickles and Sauces (Item 17)

209. At present, pickles and sauces made from fruit or vegetables may contain up to 250 p.p.m. of benzoic acid. We are informed that benzoic acid is no longer used in pickles and sauces and it has been represented that the existing provision should be replaced by one permitting up to 100 p.p.m. of sulphur dioxide. Pickles and sauces would then be on the same basis as jam and it was further proposed to us that prepared fruit for making into pickles and sauces should be allowed to contain the same amount of sulphur dioxide as the raw material for jam making. This latter request would be met by our proposals for fruit and fruit pulp for manufacturing purposes.

210. We have received representations that special provision should be made for horseradish sauce, relish and tartare. A Swedish food manufacturer exporting to this country asks for permission to use 1,000 p.p.m. of sulphur dioxide and 1,000 p.p.m. of benzoic acid. A British firm indicates that 200 p.p.m. of sulphur dioxide is necessary for adequate retention of colour and flavour on the basis of a safe shelf-life of six months.

211. We consider it would be reasonable to treat pickles and sauces on the same basis as jam and recommend that the present provision should be replaced by one permitting up to 100 p.p.m. sulphur dioxide. We do not, however, think that a strong enough case has been made out for a special higher limit for horseradish sauce.

Dehydrated Vegetables (Item 18)

212. The Preservatives Regulations allow sulphur dioxide in dehydrated vegetables up to the following amounts:

(a) potatoes	550 p.p.m.
(b) runner beans, turnips, spinach, swedes, peas, parsnips, carrots, mixed vegetables	2,000 p.p.m.
(c) cabbage...	3,000 p.p.m.

213. We have received evidence from the Scientific Adviser's Division (Food) of the Ministry of Agriculture, Fisheries and Food in co-operation with the Food Investigation Organisation of the Department of Scientific and Industrial Research about the value of sulphur dioxide in dehydrated vegetables. The sulphur dioxide conserves the colour of the vegetables during drying and adds to the storage life of the products by retarding the development of brown discoloration and by retaining a satisfactory flavour. It reduces the loss of ascorbic acid both during processing and subsequent storage, but the effect on vitamin B_1 appears to vary. In dehydrated potatoes, virtually the whole of the vitamin B_1 is destroyed, but there is some experimental evidence that the vitamin B_1 content of carrots is actually maintained with the use of sulphur dioxide.

214. We accept that the use of sulphur dioxide in dehydrated vegetables is necessary. The apparently high limits relate to the dried product and the amount ingested will be considerably less when the product has been reconstituted; we have, nevertheless, critically examined the existing limits. The manufacturers of a mashed potato powder have submitted evidence to us indicating that their product (which contains 500 p.p.m. of sulphur dioxide on manufacture) is unlikely to contain more than 250 p.p.m. by the time it is used by the consumer. On preparation for consumption it is normally diluted with hot water in the proportion 4:1 and, with a further small loss during the reconstitution, the potato mash as consumed is likely to contain no more than about 45 p.p.m. of sulphur dioxide. The Scientific Adviser's Division indicate that corresponding figures for cabbage as consumed would be 100 p.p.m. and, for carrot, 25 p.p.m.

215. The view of the manufacturers is that the present limit for dehydrated potatoes is necessary if the product is to reach the consumer with sufficient sulphur dioxide in it to prevent browning under average storage conditions. Much of the value of these dehydrated products lies in the fact that they can be kept in the home as emergency stocks. Other dehydrated vegetables are not at present consumed in any large quantities by civilians, and even on Service scales of supply they constitute only a small fraction of the total food intake.

216. The Scientific Adviser's Division advises that, as a result of technical advances which have been made since the present limit was set, it is now possible to produce dehydrated cabbage satisfactorily with a sulphur dioxide content of not more than 2,500 p.p.m. On the other hand, attention is drawn to the fact that other vegetables such as brussels sprouts, dwarf beans and leeks have now been successfully dehydrated but must be sulphited for adequate storage.

217. We have received representations from industry that dried onions should be added to the list of dehydrated vegetables in which preservative is permitted. It is claimed that dried onions have a tendency to go brown if kept for any length of time and that it would be useful to have a counteracting factor. We accept that sulphiting would give some protection against browning during drying and storage and we see no objection to preservative being allowed in dried onions as in other dehydrated vegetables.

218. We therefore recommend that the existing limits for sulphur dioxide content of dehydrated vegetables should be replaced by the following:

(a) potatoes	550 p.p.m.
(b) cabbage...	2,500 p.p.m.
(c) other vegetables	2,000 p.p.m.

Bacon, Ham and Pickled Meat*

219. The traditional method of pickling meat is by the use of a cure containing salt and saltpetre. This practice is permitted by specifically excluding sodium and potassium nitrates from the definition of "preservative" in the present Regulations. The function of the saltpetre is to discourage the growth of anaerobic bacteria which might taint the meat and to produce the characteristic pink colour of cured and pickled meats. But the latter is achieved by the reduction of the nitrate to nitrite, which is thus present in the meat as sold. Since 1940, the Preservative Regulations have expressly permitted the presence of nitrite in bacon, ham and cooked pickled meat, whether from the use of nitrates or from the direct addition of nitrites to the brine, which is the practice in some cases. A limit of 200 p.p.m. for the nitrite content was fixed in the case of cooked pickled meat but there is no limit for bacon and ham.

220. Because of the toxicity of nitrites (see Part III, paragraphs 83–86) we consider it very desirable that their use in food, if permitted at all, should be properly regulated. Similarly, we believe the use of nitrates in food should be restricted because of the possibilities of reduction to nitrites.

221. We have consulted the British Bacon Curers' Federation and, through their Embassies in London, those countries which are major suppliers of bacon and ham to this market (viz., Denmark, Eire, the Netherlands and Poland) about the possibility of fixing statutory limits for the nitrate and nitrite content of bacon and ham. The Federation question the need for such limits, bearing in mind that a substantial proportion of the nitrite content is destroyed on cooking and the fact that there have been no reports of ill effects directly attributable to the consumption of bacon or ham containing excessive amounts of nitrite. Furthermore, they point to the difficulties in controlling the nitrite content, which will be subject to variations (due to length and conditions of storage) beyond the control of the curer. In particular, it is known that the nitrite content of bacon and ham gradually increases when it is kept in sliced form, and rapidly if it is minced. Apart from any other consideration, this would make the enforcement of a statutory limit very difficult.

222. To assist us in making recommendations, the British Bacon Curers' Federation undertook to provide data on the nitrate and nitrite content of bacon and ham at various stages up to the point of retail sale and after cooking. From data supplied, it seems clear that there would be no difficulty in conforming to a limit of 200 p.p.m. for the nitrite content of bacon and ham ex factory. One hundred and seventeen samples taken at the factory showed a range of nitrite content from nil to 132 p.p.m., with all but seven of the samples less than 60 p.p.m. The nitrate content of thirty samples was more variable, ranging from 190 to 5,800 p.p.m. It also seems clear from our consultations that, except possibly in the case of Holland where domestic legislation allows up to 500 p.p.m. nitrite, imported bacon and ham would not contain more than 200 p.p.m. nitrite.

223. The principal difficulty arises, however, after the bacon and ham have been distributed to the retail shops. Here it may be sliced, with or without prepackaging, and kept for several days before it is sold. Experiments have shown that losses on cooking are variable and while the loss may be as much as 90% it may not be more than 20%. The experimental results submitted to us were as follows:

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*Regulation (1)(iv), Regulation 4(4), Regulation 11(1)(iv) and Regulation 11(3).

Reduction in Nitrite Content of Bacon and Ham on Cooking

Method of Cooking	*Number of Samples*	*Range of loss (per cent)*
Frying	31	40–90*
Grilling	35	20–75*
Commercial boiling (ham)	29	20–80

*allowing for changes in weight

224. There is some evidence that a significant rise in the nitrite content does not occur with the uncooked product until the bacon or ham becomes unacceptable to the consumer because of colour or other deterioration. Comprehensive data on the position at the point of retail sale are not yet available and the Federation has indicated that the necessary survey will take a considerable time to complete. Until such information is available it is not possible to decide whether statutory control of the nitrite (and nitrate) content of bacon and ham is necessary and, if so, what form such control should take. We therefore recommend that further consideration should be given to this matter as soon as the necessary information is available. In the meantime it will be necessary to provide for the presence of nitrate in bacon, ham and pickled meat if, as is recommended in paragraph 32, nitrates are no longer exempt from the definition of preservative.

225. We do not suggest any amendment to the present limit of 200 p.p.m. for the nitrite content of cooked pickled meat.

226. It has been represented to us that *uncooked* pickled meat should be permitted to contain added nitrite. The firm in question desire to market a wider range of meats suitable for boiling and feel this could best be done by curing the cuts in the traditional way. The direct addition of nitrite to the brine is stated to produce a better quality product and to enable the nitrite content of the brine to be more accurately controlled than with the use of nitrates. A limit of 500 p.p.m. of sodium nitrite in the raw pickled meat is suggested, and evidence is provided that this can be obtained by the manufacturer with the addition of not more than 1,000 p.p.m. of nitrite to the brine. The meat, after cooking, will not then contain more than 200 p.p.m., the present limit for cooked pickled meat. Furthermore, tests with beef pickled in a mixture of nitrate and nitrite indicated that, unlike bacon and ham, there was no rise in the nitrite content after storage for two weeks. We recommend that provision should be made for the presence of not more than 500 p.p.m. of nitrite in uncooked pickled meat.

Citrus Fruit*

227. The provision in the Regulations which allows citrus fruit to contain diphenyl by virtue of it having been wrapped (outside the United Kingdom) in diphenyl-impregnated wraps is unique in that the quantitative limit is set on the wrapping material instead of the food itself.

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*See also footnote on page 3.

228. It has been represented to us that the continuation of this provision is desirable in the interests of the consumer. The use of diphenyl-impregnated wraps is an effective means of controlling mould growths, thus reducing the wastage of fruit imported into this country. It has been estimated that the loss of oranges in this way can be reduced from as much as 25% of a shipment to as little as one or two per cent. Such of the diphenyl as is transferred to the orange remains in the peel and only the merest traces penetrate into the pulp; it is thus only products containing the peel which involve the ingestion of measurable quantities of diphenyl. The evidence discussed in Part III indicates that no health hazard is likely to arise from the amounts which could conceivably be ingested in this way. With comminuted orange drinks there is a further safeguard that diphenyl may introduce an undesirable flavour into the product and thus only oranges which contain no diphenyl or a very low concentration are likely to be used for this purpose.

229. We agree, therefore, that the use of a preservative for citrus fruit should continue to be permitted; but we consider that it would be more appropriate to control its use by placing a limit on the content of preservative in the fruit itself. This offers greater protection to the public by direct limitation on the amount of preservative and by being readily enforceable by analysis. It will also make possible the use of alternative methods of preservation (e.g., the packing of unwrapped oranges in cartons with diphenyl-impregnated pads) which are known to be in use in some countries. We recommend the replacement of the existing provision by a limit of 100 p.p.m. diphenyl on or in the whole fruit. Such a limit should amply cover the amount of diphenyl likely to be found in fruit from the use of impregnated wraps of the concentration allowed at present.

230. We have also received representations in favour of allowing the use of o-phenylphenol as a preservative in citrus fruit. This is used in the form of a 0·15–2·0% solution of sodium o-phenylphenate into which the fruit is dipped for up to 3 minutes. The United States Food and Drug Administration has specified a tolerance of 10 p.p.m. o-phenylphenol in citrus fruit (compared with 110 p.p.m. for diphenyl) but it is claimed that this level would be inadequate to preserve fruit exported to this country. A concentration having similar fungicidal efficiency to the diphenyl wrap conforming to the present provision results in an average residue in the fruit (at least nine-tenths of which is in the peel) of about 60 p.p.m. o-Phenylphenol, unlike diphenyl, does not appear to have any adverse effect on the flavour of products such as comminuted orange drinks, made from treated fruit.

231. The Pharmacology Panel are satisfied that the use of o-phenylphenol or its sodium derivative as proposed would present no health hazard (see paragraph 127). We therefore see no objection to their use being permitted as a preservative for citrus fruit as an alternative to diphenyl and consider that an appropriate limit would be 70 p.p.m. (calculated as o-phenylphenol) on or in the whole fruit.

232. We have also been advised that it is the practice in the United States to dip citrus fruit in a solution of sodium o-phenylphenate and then to pack the fruit in containers with diphenyl-impregnated pads; thus the fruit may contain quantities of both preservative. We see no objection to the two preservatives being present in admixture provided (on the formula suggested in paragraph 46) the total amount of preservative present is not greater than would be tolerated if only one preservative were used.

B. FOODS NOT AT PRESENT PERMITTED TO CONTAIN PRESERVATIVE

Bread

233. In a memorandum submitted to us, the British Baking Industries Research Association drew attention to the difficulties confronting the baking industry in the control of rope and mould development in bread, and represented that use of preservative is desirable to prevent wastage on these accounts.

234. The composition of flour and bread is at present the subject of review by the Food Standards Committee; but it was felt that recommendations on the use of anti-mould agents in bread could more appropriately be made in this report.

235. Rope, a condition in bread which makes it unpalatable, is caused by the presence of spores of rope-producing bacteria (bacillus mesentericus) in the raw materials. Mould infection usually arises after baking from mould spores contained in equipment or the atmosphere; the appearance of mould and its musty flavour leads to rejection of the bread.

236. Acetic acid, which is expressly excluded from the definition of "preservative" in the existing Regulations, is effective against rope and is used in bread during hot weather. The use of acid calcium phosphate for the same purpose was also expressly recognised in the regulations which governed the composition of National Bread during the control period, and we have already recommended (paragraph 33) that any doubt as to the status of this substance under the Preservatives Regulations should be resolved by including it in the list of exemptions. There are thus means already available to the baker for dealing with rope infection, although it has been suggested that the use of other substances (which are also effective against mould) should be permitted.

237. The situation is different so far as mould growth is concerned in that none of the substances which are effective against mould spores is allowed under the existing Regulations. Infection of bread with mould can be considerably reduced by the adoption of hygienic practices in the bakery and the use of appropriate formulae and baking methods. But neither is completely effective during spells of hot humid weather and it is the view of the baking industry that, in the absence of permission to use anti-mould agents, the problem is a serious one.

238. The wastage of bread due to mould is difficult to estimate, particularly as it must occur most widely in the home and often cannot be separately assessed from that due to staling. A survey in the United States in 1934 indicated that about 1% of the total bread produced was lost annually through mould development. Figures published in Germany in 1954 gave losses of 1% for white bread, 6% for wheat and rye breads and 20% for black, wholemeal and sliced breads. Comparable figures for the United Kingdom are not available but it has been suggested that during the three summer months wastage may be of the order of 5%. Assuming that losses during the remaining months are negligible, this could mean the wastage of about 1% of the bread produced annually, the retail value of which would be more than £2 million. Besides the economic loss involved, the prevalence of mould growth leads to complaints from the consumer and results in the baker being prosecuted under the general provisions of the Food and Drugs Acts. In this respect, mould is a more serious problem for the baker than staling.

239. The growth in the sale of wrapped and sliced breads has greatly aggravated the problem. With sliced bread, mould readily develops between the slices. Wrapping increases the risk of mould development because evaporation from the bread raises the relative humidity of the air between the bread and the inner surface of the wrapper: thus an unwrapped loaf which remains free of mould for 3 or 6 days may, when wrapped, remain mould free only for 2 or 4 days respectively.

240. We are satisfied that there is a case for allowing the use of an anti-mould agent in bread. There is ample evidence that mould growth can be effectively prevented by the addition of quite small amounts of suitable anti-mould agents. The standard for bread in the United States allows the use of calcium or sodium propionate up to 0·32% by weight of flour used. Experiments conducted in this country indicate that the addition of 7 or 8 oz. of calcium propionate per sack of 280 lb. (equivalent to about 0·2% by weight of flour used) would provide the commercial bakery with a reasonable safeguard against both rope and mould in bread. The use of sodium diacetate is also allowed in bread in the U.S.A. and Canada up to limits similar to those for the propionates, but it is more expensive and we believe there would be little call for it in this country if propionates were allowed. Representations have been made to us that dehydroacetic acid is about ten times as effective against mould as calcium propionate and ought therefore to be permitted, but in view of its possible toxicity (see paragraphs 104–107) we cannot recommend its use in bread. Sorbic acid, though highly effective against moulds, is not suitable for use in bread because it imparts an undesirable aroma and flavour and may, in sufficient concentration, impair fermentation.

241. It is our opinion, therefore, that provision for the use of an anti-mould agent in bread should be confined to propionic acid and its salts. It has been suggested to us that no statutory limitation on the quantity to be used is necessary and that these substances might be excluded from the scope of the Regulations altogether, but we do not think this would be wise in view of the important place which bread occupies in the diet. We therefore recommend that provision should be made to allow the presence in bread of not more than 0·3% (by weight of flour used) of propionic acid or an equivalent amount of calcium or sodium propionate, or a mixture of any of these.

242. Our recommendation is intended to apply to all types of bread including such bakery products as rolls, crumpets, etc., which are susceptible to mould growth; this is without prejudice to any definition of "bread" which may be included in the recommendations of the Food Standards Committee.

Cakes and other flour confectionery

243. Certain types of cakes are particularly liable to mould growth because of their high relative humidity. We received evidence from one large distributor that during the summer of 1956 there were substantial losses, as well as complaints from the public, due to mould growth on the surfaces of sliced, wrapped cakes. Trouble is also experienced with slab madeira-type cakes.

244. Sodium and calcium propionate have been used in America in cakes, but more recent evidence indicates that sorbic acid is at least twice as effective as calcium propionate in cakes of the madeira type and about four times as effective, weight for weight, in cakes with a high sugar : fat ratio. It imparts no undesirable flavour to the cakes. The United States Food and Drug Administration sees no objection to the use of sorbic acid in concentrations up to 0·3% of

flour weight in cakes and other baked products for which there are no formal standards of identity. It is allowed in bakery products in Canada up to 1,000 p.p.m. of the product.

245. Application has been made that sorbic acid should be permitted in this country as a preservative in bakery products. The amounts likely to be used commercially are of the order of 0·2% of the weight of the flour, or less. We consider that the permissive use of this substance would be in the interest of the consumer and we recommend that flour confectionery should be allowed to contain not more than 1,000 p.p.m. of sorbic acid or an equivalent amount of sodium sorbate.

Poultry

246. We have received fully documented submissions from chemical manufacturers proposing the use of the antibiotics oxytetracycline and chlortetracycline in the preparation of chilled eviscerated poultry. The proposals are supported by trade organisations representing packers of poultry (including turkeys).

247. Because of the fast rate of spoilage from the growth of bacteria in eviscerated carcases, the usual practice in this country has been to sell poultry uneviscerated or else to carry out this operation at the point of retail sale. The sale of pre-packed "oven-ready" poultry has, however, been developing rapidly in recent years and a survey has indicated that in 1956 almost half the output of poultry packing stations in Great Britain was in eviscerated deep frozen or chilled carcases. It is claimed that treatment with antibiotic during processing inhibits bacterial growth thus increasing the shelf-life of the eviscerated carcase and providing the consumer with a product in better condition. In the United States, where its use has been allowed since November, 1955, the processing of fresh killed poultry with antibiotic is now a routine commercial practice; refrigeration of poultry during transport and marketing is, however, much more highly developed than in the United Kingdom. Whether the use of antibiotics would develop similarly in this country we are unable to say, but any additional protection from spoilage afforded to this perishable commodity would clearly assist sales of pre-packed eviscerated poultry for which there is a demand.

248. The proposed method of application is to add the antibiotic (in amounts equivalent to approximately 10 p.p.m.) to the water and ice in which the eviscerated carcases are placed. The carcases are left in the cooling tank for up to two hours, during which time their temperature falls to 34°–37°F., and are subsequently stored at this temperature. We are informed that experiments conducted on a commercial scale indicate that dipped poultry so treated is acceptable when cooked after 17–21 days, whereas the product without antibiotic has a life of only about 10–14 days. The apparent increase in shelf-life would be appreciable. The manufacturers emphasise, however, that this extension is only obtained under suitable conditions. The representations made to us emphasise that antibiotics are less effective in combating spoilage which has already started and that they are not therefore a substitute for hygienic methods of handling at the packing station. There is also evidence that the effectiveness of the antibiotic is dependent on the subsequent storage conditions and that there is no worthwhile extension of storage life if the treated carcases are stored at ordinary temperatures.* It is presumably for these reasons that one of the companies marketing antibiotics in the U.S.A. will only supply its product to

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*J. Sci. Food Agric. August, 1957 page 485.

users prepared to enter into an agreement which includes compliance with certain standards of hygiene and refrigeration.

249. With the proposed method of treatment, the amount of antibiotic in the treated raw poultry is generally of the order of 1–2 p.p.m., though the skin may occasionally contain as much as 6 p.p.m. After ordinary cooking, however, the residue of active tetracycline ranges from amounts too small for detection to 0·4 p.p.m. (the latter amounts usually being found only in the skin).

250. The Antibiotics Panel does not consider that the presence of up to 7 p.p.m. of chortetracycline or oxytetracycline in the raw poultry would in itself be objectionable on medical grounds, but they expressed some reservations about the possibility of the treatment increasing the risk of food poisoning. If the treated poultry could always be maintained at a sufficiently low temperature this problem would not arise, but the difficulties of ensuring this throughout distribution and until the carcase is cooked in the home or elsewhere are formidable. Until further investigations have been completed, the Panel is unable to give a final opinion as to whether, and if so to what extent, failure to maintain the necessary temperature throughout involves a health hazard. We are therefore unable to recommend that any provision should at present be made for the use of these antibiotics to preserve eviscerated poultry.

Fish, and fish and whale products

251. The further major use for oxytetracycline and chlortetracycline about which definitive proposals have been made to us is the preservation of fish. Three possible usages are envisaged; the incorporation of approximately 5 p.p.m. of the antibiotic in the ice or refrigerated sea-water used to store freshly caught fish in the holds of trawlers; incorporation in the ice in which fish is packed during distribution from the docks to the retailer; and the dipping of fish fillets at the time of filleting in a solution containing 5–20 p.p.m. of the antibiotic.

252. The British Trawlers' Federation has indicated its interest in this possible development and a number of other organisations connected with the fishing industry have supported the applications made to us by the antibiotic manufacturers. Experiments conducted with British distant water trawlers indicate that fish keeps for 2–3 days longer when the ice in which it is stored has been treated with antibiotic. It is claimed that such an extension is of considerable economic significance to the industry, allowing longer voyages, reducing the risks of spoilage of the fish at sea, and enabling the consumer to be offered a better quality product.

253. The problems of storing and distributing such a perishable food as fish are formidable. We accept that anything which can be done to supplement commercial methods of hygienic handling will be of assistance to the trade and of indirect benefit to the consumer. Although the extended protection offered by the use of antibiotics may not appear very great, we consider that their use on fish would be justified provided there was no objection on health grounds. The Antibiotics Panel has advised, however, that the possibility of medical disadvantage in allowing the treatment of fish cannot be wholly excluded since the evidence so far available indicates that the amount of antibiotic likely to be present in fish after cooking is not insignificant. In view of this, we are unable to make any recommendation at this stage in regard to the proposed use of chlortetracycline and oxytetracycline on fish.

254. We have received representations that the use of sodium nitrite should be permitted for the same purpose and in the same way as the proposed treatment of ice with antibiotic. It is claimed that the addition of 0·1% of nitrite to the ice, giving a concentration of about 200 p.p.m. in the fish, is sufficient to prolong the "freshness" of the fish judged by taste, smell, etc. by 3–4 days. On the other hand, figures supplied to us by the Torry Research Station indicate that a concentration of 0·15% in the ice is necessary and that this may produce 300–400 p.p.m. of nitrite in the fish after 10–16 days storage. Moreover, there is no appreciable reduction in the concentration of nitrite on cooking. The colour and taste of the fish are also stated to be adversely affected. In the circumstances, and having in mind the desirability of reducing the ingestion of nitrites to a minimum, we do not recommend that the use of sodium nitrite in fish should be permitted.

255. Our attention is also drawn to investigations in Germany with the addition of sulphonamides and hydrogen peroxide to ice for the preservation of fish. No detailed evidence was submitted and we would not in any event wish to recommend that either of these substances should be so used.

256. We have received evidence of the effectiveness of treating **whales** with chlortetracycline at the time of killing so as to delay bacterial spoilage before and during the processing of the carcase. Owing to the slow cooling of the great mass of the whale, advanced bacterial decomposition can occur within 24 hours of death, leading to losses in both the quality and the quantity of the products obtained. The introduction of antibiotics equivalent to about 1 p.p.m. of the carcase weight, either through the harpoon head or the pipe used to inflate the carcase, may, according to one estimate, delay the onset of decomposition sufficiently to double the yield of whale meat and increase the yields of whale meat extract and animal feeding meals by 30% and 10% respectively, as well as improving the quality of the products. It is also suggested that whale meat might be treated directly either by dipping in antibiotic solution or by packing in antibiotic ice.

257. These proposed uses only concern us in so far as the end products go into human consumption. Much of the whale carcase goes for animal feed, and we are informed that the only products which are offered for human consumption are whale oil and whale meat extract. Tests have been undertaken which, as the report of the Antibiotics Panel states, indicate that the normal commercial processes for these products are sufficient to destroy the chlortetracycline so that no detectable amounts remain in the oil or extract. On this basis, the Antibiotics Panel is satisfied that no health hazard exists, and we for our part would see no objection to the practice. To permit the sale or supply of antibiotics for this purpose without a prescription, regulations would have to be made under Part II of the Therapeutic Substances Act, 1956 (under which the advice of the Medical Research Council needs to be sought before relaxation of the Act can be made); but there does not appear to be any need to make specific provision in the Preservatives Regulations since the food will not be expected to contain any residue.

258. We have received a number of representations from firms in Scandinavia and importers in this country about a variety of **fish products** which are marinated or cured but not sterilised. They include cured herrings and brisling, smoked salmon, eel and cod roe, lumpfish roe and anchovies. The fish are variously cured with salt, acetic acid, spices and sugar. These should give the products sufficient acidity to prevent the development of pathogenic organisms, but they

have a limited shelf-life without refrigeration because of the rapid bacterial spoilage. It is claimed that the addition of a preservative would reduce wastage and considerably extend the marketing possibilities. It is pointed out that many European countries permit the use of benzoic acid or some other preservative such as hexamethylenetetramine for this type of product. Experiments in Norway indicate that 1,000 p.p.m. of benzoic acid would extend the shelf-life of anchovy fillets to 2–3 months at ordinary temperatures; but higher amounts are requested by other firms and the British Food Manufacturing Industries Research Association suggest that the amount of benzoic acid necessary for adequate preservative action would be regarded as excessive in this country. The Association suggests that consideration should be given to the use of one of the esters of p-hydroxybenzoic acid on the grounds that they are of lower toxicity than benzoic acid. It has also been suggested that sorbic acid would be of value in preventing development of mould in smoked and salted fish.

259. Many cases of food poisoning due to fish products have been reported in countries where the use of preservative is permitted. Moreover, the amount of preservative necessary to secure a significant increase in shelf-life is substantial. As indicated elsewhere in our report, we are concerned to restrict the use of preservatives like benzoic acid as much as possible; nor do we regard the para-hydroxybenzoic acid esters as being significantly less toxic than benzoic acid. We therefore consider that if these fish products are to be marketed in this country, they should be distributed under refrigerated conditions and not permitted to contain a preservative. Nor do we think a case for allowing sorbic acid in smoked and salted fish has been made out.

260. Representations have also been made for open pack fish paste to be allowed to contain up to 450 p.p.m. of sulphur dioxide. The considerations are similar to those in respect of open pack meat paste, and for the reasons given in paragraph 293 below we do not recommend that this should be permitted.

Raw Peeled Potatoes

261. It is known that many fish friers prepare peeled potatoes ready for chipping and frying by dipping them in a weak solution of sulphur dioxide, a practice which has apparently not been thought to contravene the present Regulations. The evidence is that such chips do not contain detectable quantities of sulphur dioxide and the effect on their vitamin B_1 content is probably small. We see no objection to the continuation of this practice provided the potatoes are dipped while they are still whole and not chipped first. If potatoes which have already been chipped were treated in this way, the effect on the vitamin B_1 content would be much greater even though the cooked chips were still free from sulphur dioxide. No special provision is, however, called for in the Regulations since on sale the cooked chips would not contain preservative.

262. We have received a representation that provision should be made to permit the addition of sulphur dioxide to raw peeled potatoes for retail sale in pre-packed form. Other processes will be used to give the product an adequate shelf-life, but some sulphur dioxide treatment is necessary to prevent browning. The firm proposes to market raw chips and possibly whole peeled potatoes. The concentration of sulphur dioxide will be of the order of 50 p.p.m., though a limit of 100 p.p.m. on the raw potato is requested. Tests have shown that, after cooking, the chips will contain less than 10 p.p.m.

263. It is clear that such a trade in pre-packed peeled potatoes is unlikely to account for more than a very small proportion of the total consumption of

potatoes. The amount of sulphur dioxide proposed is similar to that normally present in dehydrated potatoes on a comparable reconstituted basis, and when allowance is made for the loss on cooking the amount likely to be ingested is almost negligible. On the other hand, as in the case of dehydrated potatoes, the combined effect of the sulphur dioxide and the other processes involved is to destroy a very large part of the vitamin B_1 content.

264. In this case, the loss of vitamin B_1 need not be regarded as serious since no individual or family is likely to rely entirely on potatoes in this relatively expensive form. Potatoes are nevertheless an important source of vitamin B_1 in the diet* and the widespread sulphiting of potatoes would be undesirable. Proposals have been mooted for marketing peeled raw potatoes to caterers, relying largely on sulphur dioxide to preserve them for the necessary length of time. There are practical difficulties in this, including possible adverse effects on taste, but the concentrations likely to be used are such that the residual sulphur dioxide, especially if the potatoes are treated and marketed in chipped form, might be substantial. Thus, if such a trade were to develop on a large scale, it could lead to a significant increase in the intake of sulphur dioxide as well as a reduction in the contribution by potatoes of vitamin B_1 to the diet. We therefore recommend that raw peeled potatoes (including chips) should be allowed to contain not more than 50 p.p.m. of sulphur dioxide (which ought to be sufficient for the purpose indicated in paragraph 262) but that this concession should be reviewed if potatoes so treated seem likely to constitute a substantial proportion of the purchases of potatoes by any section of the community, and if it becomes practicable to market peeled potatoes by retail without the use of sulphur dioxide. We would point out that this provision will not affect the practice of fish friers which we have already discussed, since it will apply only to sale of the raw potato.

Non-Citrus fruits†

265. We were asked by Departments to consider the use of sodium o-phenylphenate for the post harvest treatment of certain non-citrus fruits in view of the existence of legal tolerances in the United States and Canada, and the desire of U.S. exporters to send treated fruit to this country. The current tolerances established in North America are: pineapples 10 p.p.m.; peaches 20 p.p.m.; apples and pears 25 p.p.m.; and cantaloupes 125 p.p.m. of o-phenylphenol. For the reasons given in Part III (paras. 122–127) we would see no objection on health grounds to allowing the presence of up to 10 p.p.m. of o-phenylphenol in apples, pears and pineapples, 20 p.p.m. in peaches and 125 p.p.m. in melons. Nevertheless, the treatment of non-citrus fruits with o-phenylphenol, particularly those which may be eaten in substantial quantities without peeling, should not in our view be permitted unless it has been shown that such treatment is necessary for the distribution of the fruit in good condition. So far as we have been able to ascertain, the United States is the only country at present treating fruit for export to this market, and there have been no requests from fruit growers or chemical manufacturers for the use of o-phenylphenol in this country. We do not feel that the evidence so far available justifies us in recommending an amendment to the Regulations.

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*According to the National Food Survey, potatoes provide 15% of the average vitamin B1 intake of all households and 19% in the case of families with four or more children.

†See also footnote on page 3.

Cheese

266. The growth of mould on cheeses presents the manufacturer and distributor with a number of problems, and an application has been made by the National Association of Creamery Proprietors and Wholesale Dairymen to allow the use of certain antimycotic agents on cheese rinds, bandages and adhesives. This application is supported by the Milk and Milk Products Technical Advisory Committee appointed by the Minister of Agriculture, Fisheries and Food and the Secretary of State for Scotland. It is pointed out that there is a growing consumer preference for clean coated cheese. Because of the seasonal nature of cheese manufacture and for other technical reasons, it is impossible to provide a continuous supply of cheese free from mould growth throughout the year. Mould also creates a problem by tending to obliterate the grade markings which are put on whole cheeses soon after manufacture. Finally, the uncontrolled growth of surface mould affects the cheese itself and this leads to much wastage; it has been estimated that in the U.S.A. more than 13 million pounds of cheese (representing over 1% of total cheese production) would be saved annually by the use of suitable fungistatic wrappers ('Food Technology' 1954, Vol. 8, No. 3, pps. 133–135).

267. It is proposed that mould growth should be controlled by treating the cheese bandage (or the adhesive used for fixing it to the cheese) with dehydroacetic acid or sorbic acid at a rate equivalent to 1·5 gm. per 50 or 56 lb. cheese. In both cases there is considerable migration of the anti-mould agent into the cheese itself. Experiments carried out by the National Institute for Research in Dairying indicate that, with the surface treatment of cheeses with dehydroacetic acid at the rate of 2·2 mg. per square inch, about 60% of the acid penetrated into the cheese after a month's storage, but that 70% of this quantity was concentrated in the first ¼in. including the rind. The concentration of dehydroacetic acid in the whole cheese appears to be less after four months' storage (ranging from 7–15% of original treatment, compared with 23–48% after one month). So far as sorbic acid is concerned, evidence submitted by manufacturers of sorbic acid indicates that after 6 weeks less than 10% of the original sorbic acid remains in the wrapper. It is pointed out that if the cheese were wrapped in paper containing 5·0 gm. of sorbic acid per 1,000 sq. in. and the whole of the sorbic acid transferred to the cheese, a ½ lb. package of cheese might contain 900 p.p.m. of sorbic acid. The treatment of cheese with an oil solution containing 5% of ethyl p-nitrobenzoate has also been suggested. By this process it is stated that a 28 lb. cheese would contain about 800 p.p.m. of preservative.

268. We are satisfied that a prima facie case has been made out for allowing the use of a suitable anti-mould agent in cheese bandages. We are of the opinion, however, that it would be desirable, at any rate for the time being, to make provision only for the use of sorbic acid, which is effective and free from objection on health grounds. Although we understand the practice is to add the preservative to the bandage or the adhesive, it will be in conformity with our general recommendations (in Part II) if this practice is permitted by allowing cheese to contain an amount of sorbic acid approximately equivalent to the amount necessary for the effective control of mould growth on the surface. We therefore recommend that provision should be made for cheese to contain not more than 1,000 p.p.m. of sorbic acid.

269. The manufacturers interested in marketing sorbic acid also draw attention to its use to prevent mould in processed cheese, either by using impregnated

wraps (effective at levels of 2·5–5 gm. per 1,000 sq. in.) or by adding it to the cheese during processing. At this concentration, it is said to have no adverse effect on taste, odour, colour or emulsion stability. We are not aware of any real problem from mould growth in processed cheeses but recognise that, if the natural cheeses used in its manufacture have been wrapped in impregnated bandages, some amount of sorbic acid may be present in the processed product. This will be allowed for by the operation of the "carry-over" provision (see paragraph 48) and we do not consider that any additional provision for processed cheese is called for.

270. Reference has already been made to the possible use of the antibiotic, nisin, in natural cheeses, processed cheeses and cheese spreads. Nisin occurs naturally in French cheeses made from soured milk, since this is likely to contain nisin-producing streptococci, and in factory produced Cheddar and Cheshire cheeses (and occasionally other British cheeses). The amount of nisin present is usually in the range 0·025–2·5 p.p.m. but it may be as much as 10 p.p.m. if nisin-producing strains are used as starters. Cheeses in which nisin occurs naturally are not liable to clostridial spoilage, and no advantage is obtained by adding nisin. But the low acid sweet cheeses such as Gruyère, Emmental, Samsoe, Edam and Gouda and hard cheeses of the Parmesan type are very prone to clostridial spoilage. This causes "blowing" and other forms of deterioration. It is stated that 8–10,000 tons of cheese are lost annually in this way in Denmark and that Parmesan manufacturers have recorded losses as high as 30% due to clostridia. The use of nisin-producing cultures as cheese starters or the direct addition of 2–3 p.p.m. of nisin prevents or reduces this kind of spoilage. Cheeses so treated imported into this country are likely to contain 0·025–2 p.p.m. of nisin, though amounts up to 10 p.p.m. have been recorded.

271. As regards processed cheese and cheese spreads, the addition of 2–4 p.p.m. of nisin is said to prevent spoilage due to the germination of spores of clostridia and bacilli surviving after processing. After cooking (normally in the range 80–90°C. for 3–5 minutes) the residual nisin is about 1·5–3 p.p.m. and it is stated that this is only effective if satisfactory raw materials are used and the product is processed and packed under hygienic conditions.

272. The Antibiotics Panel see no objection to the use of nisin in cheeses. Even if it were desirable to do so, it would be impossible to set a statutory limit to the amount which could be present in view of the variable amount of nisin which may be present naturally. We propose that the addition of nisin to cheese (including processed cheese and cheese spread) should be specifically permitted, without restriction in the Regulations as to quantity.

273. We understand that it is the practice to add small quantities of nitrate to certain Dutch cheeses, but no information is available to us of the reasons for this, or whether the same effect could be achieved by other means. Our proposal to remove nitrates from the list of substances excluded from the definition of preservative and to permit their use only in cured meats will prevent the importation into this country of cheeses containing nitrate.

Flavouring Syrups and Emulsions

274. A number of requests have been made for permission to use benzoic acid or another preservative in various emulsions and syrups used for flavouring purposes. In the first place, the manufacturers of flavouring compounds represented to us that provision should be made for syrups used in the preparation

of such products as ice lollies and milk shakes to contain the same amount of preservative as concentrated soft drinks. The composition of these syrups is basically the same whether they are for use in milk-based drinks or water-based products like ice lollies; they may contain fruit juices or be artificially flavoured. Products of the same kind are also sold by retail, primarily for the flavouring of milk drinks in the home, though they are apparently also used for flavouring puddings and other foods. We consider that it would be reasonable to provide explicitly for flavouring syrups to contain not more than 800 p.p.m. of benzoic acid.

275. The Pharmaceutical Society and manufacturers of pharmaceutical products have made special representations about fruit syrups, commonly syrup of raspberry or blackcurrant, which are used to flavour medicines. For dispensing purposes, pharmacists keep a stock bottle of syrup which may be repeatedly opened over a period of several months. The preservatives at present permitted are said to be unsatisfactory, sulphur dioxide causing discoloration and adversely affecting flavour, and the amount of benzoic acid allowed (up to 600 p.p.m.) being insufficient to prevent fermentation under the conditions of use. It is requested that up to 2,000 p.p.m. of benzoic acid (or a mixture of benzoic acid and methyl- or propyl-hydroxybenzoate) should be permitted in these products, suitably labelled; or alternatively that, when sold by wholesale, suitably labelled, they should be exempt from the Regulations altogether. Although the amount of benzoic acid likely to be ingested in this way is small, the concentration in the product is high; moreover, complete exemption from the Regulations would permit the use of any preservative. If special provision is to be made for these products, we think it should be done by way of the first alternative. For sales other than by retail these syrups will (if our recommendation in Part II, paragraph 40 is accepted) be allowed to contain more than the suggested limit for retail sale of 800 p.p.m. of benzoic acid provided the actual benzoic acid content is declared. We think this should be sufficient to meet the needs of pharmacists.

276. Further representations relate to "flavouring emulsions" used, for example, by the soft drinks industry as a convenient way of handling and dispensing essential oils. It is requested that they be allowed to contain 2,000 p.p.m. of benzoic acid. Since such products are diluted many times before consumption, we see no objection to higher amounts of benzoic acid being allowed, and again, our proposal in paragraph 40 would permit this on sales other than by retail provided the benzoic acid content is declared.

277. If experiments at present being conducted indicate that sorbic acid is as effective in these emulsions as benzoic acid, we would see no objection to its use being allowed as a replacement or as an alternative.

Canned Foods

278. It has been represented to us that one of the main uses of nisin would be in a wide range of canned soups, vegetables, fruits and other canned products. Nisin is not only effective in destroying the vegetative cells of clostridia but also has the effect of lowering the thermal resistance of spores. Two advantages are therefore claimed for its use. It can virtually eliminate thermophilic spoilage, e.g., "flat sours" and "hard swells", which is said to occur quite extensively with canned foods exported to hot climates or shipped in too-warm conditions. Secondly, it permits some reduction in the amount of thermal processing necessary, with consequential improvements in the quality and some economies for the processor. It is further claimed that by allowing modifications in the cooling

procedures, the use of nisin will reduce the risks from spoilage or pathogenic organisms entering the cans after the heat processing. Evidence has been presented to us from a wide range of trade and other sources as to the value of nisin on one or other of these accounts. We accept that the addition of nisin to canned foods would carry advantages for the consumer.

279. Details of the canned foods to which the addition of nisin has been shown to be advantageous, and the amounts of nisin likely to remain in the food after processing, are given in the Report of the Antibiotics Panel (Appendix IV). The Panel conclude that, from the point of view of possible hazards, a distinction must be drawn between those canned foods where heat processing (whether the use of nisin is permitted or not) will be sufficient to destroy Cl. Botulinum spores or where the pH of the product is such that there is no risk of botulism, and products where these conditions may not obtain. In the latter cases, they feel that the use of nisin could increase the risk of food poisoning, but see no objection on medical grounds to the use of nisin where there is no risk of botulism. We therefore recommend that provision should be made for the addition of nisin to canned foods, defined as "foods in hermetically sealed containers which have been sufficiently heat processed to destroy Clostridium Botulinum,* or the pH of which is less than 4·5". With such a definition, we do not think it necessary or practicable to specify the particular canned foods which may be so treated. It will automatically exclude those such as canned clotted cream, olives in brine, marinated fish and pasteurised canned hams about which the Antibiotics Panel have reservations.

280. We are informed that the amount of nisin added is never more than about 5 p.p.m. and, after processing, the residual nisin is normally less than 1 p.p.m. (except with canned fruits, where it may be up to 2 p.p.m.) and even this disappears, in many cases within a few days. When consumed, canned foods are unlikely to contain detectable amounts of nisin. We do not think it necessary to specify a statutory limit to the amount of nisin which may be present.

Drinking Chocolate Concentrates

281. Representations have been made by a firm marketing drinking chocolate concentrate that it should be allowed to contain 700 p.p.m. of sodium benzoate. Without a preservative, the product is liable to ferment and acidify after a few days, and this is said to affect the home market as well as to preclude an export trade. It is pointed out that 700 p.p.m. of sodium benzoate is allowed in similar products in the United States and further that, after dilution, the drink will only contain approximately 120 p.p.m. of preservative. We recommend that the proposed limit of 700 p.p.m. should be accepted.

Dry Root Ginger

282. It has been represented to us that certain difficulties have arisen from the presence of small amounts of sulphur dioxide in dry root ginger imported into this country. Before use, the ginger is pulverised and often mixed with other spices; the amount of sulphur dioxide likely to be ingested is therefore very small. The firm request that a tolerance of 150 p.p.m. should be allowed.

283. We do not see any objection to the use of a limited amount of sulphur dioxide in dry root ginger and recommend that the proposed limit should be accepted.

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*The conditions for this are defined in the Report of the Antibiotics Panel.

Cream

284. Manufacturers of borates have suggested that these preservatives might be useful to small farmers who make cream; but we would favour neither a return to the use of borates in food nor the addition of a preservative to cream.

Imitation Cream

285. There has in recent years been considerable discussion about the possibility of allowing the use of hydrogen peroxide or other bacteriostatic agent in imitation cream.* The intention would be to control the growth of pathogenic organisms while the imitation cream is being whipped and handled in the bakery for use in flour confectionery. It is extremely difficult to exclude any possibility of contamination at this stage and infected imitation cream may be kept for some length of time under conditions which are favourable to the growth of bacteria. The concentration of hydrogen peroxide necessary to inhibit the growth of pathogenic bacteria is dependent on the composition of the product, but a range of 0·005%–0·02% is considered adequate, provided the keeping time does not exceed seven days and provided the initial bacterial count is low: hydrogen peroxide is said to be ineffective if the imitation cream is already heavily infected. There is some danger that at the concentrations suggested the hydrogen peroxide will produce off-flavours, but provided this can be overcome, and provided the addition can be made by bakers producing their own imitation cream as well as by the large manufacturers who supply the baking industry, the British Baking Industries Research Association recommend that hydrogen peroxide should be permitted for use in imitation cream. The National Association of Creamery Proprietors and Wholesale Dairymen also think that this should be considered.

286. In view of the opinion of the Pharmacology Panel on the use of hydrogen peroxide as a food preservative (paragraph 134), we feel unable to approve its use even if there were a case for allowing (or requiring) the addition of a preservative to imitation cream.

Other Confectionery Ingredients

287. Among the representations we received were a number relating to the possible use of preservatives in certain ingredients used by the bakery and confectionery trades. Several requests were made for permission to use sorbic acid in **marzipan.** While we do not think that, under suitable conditions, the ordinary handling of marzipan in bulk need be a serious problem, we accept that there may be circumstances where marzipan (especially when pre-packed) may have to be stored for some time under conditions which are conducive to mould growth. We would see no objection to the addition of up to 1,000 p.p.m. of sorbic acid to marzipan.

288. It is also suggested that sorbic acid or some other suitable anti-mould agent should be allowed in **sweetened desiccated coconut,** because it is susceptible to fungal attack during storage. Mould growth might cause wastage because of the development of a soapy flavour, but no evidence of the practical importance of this problem has been submitted. We do not recommend that any provision should be made for the addition of preservative.

289. Representations have also been made that **mincemeat** has an insufficient concentration of soluble solids to protect it from yeast and mould growth and

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*See, for example, Hobbs and Smith, *The Journal of Hygiene*, Vol. 52, No. 2, June, 1954, pps. 230-246.

that it should be allowed to contain ethyl vanillate. It is stated that acetic acid (excluded from the definition of "preservative") has been used in the past but that it has an adverse effect on flavour. Enquiries have revealed that vanillic acid esters are not normally manufactured in this country and, although effective as anti-mould agents, they are comparatively expensive. For this reason, and because of the paucity of pharmacological evidence (see Part III, paragraphs 128–131), we do not consider that a sufficient case has been made out for the use of these esters as preservatives to be permitted.

Vinegar

290. The Food Manufacturers' Federation represented to us that provision should be made to deal with residual traces of sulphur dioxide in vinegar resulting from the sterilisation of casks with bisulphite solution. This treatment is necessary to keep the casks free from mould and other organisms while they are in store. It is suggested that the present limit for beer of 70 p.p.m. should also apply to vinegar. We see no objection to this, and recommend accordingly.

Open-pack Meat Paste

291. We have also received representations from the Food Manufacturers' Federation that open-pack meat (and fish) pastes should be allowed to contain 450 p.p.m. sulphur dioxide. It is stated that such an amount would be insufficient to counteract a high initial bacterial count but would assist in maintaining in good condition a product which is very vulnerable to bacterial contamination after manufacture.

292. These products, which are more popular in the North and Midlands than in Southern England, consist generally of a mixture of beef, cereal filler, gelatin, gravy and seasoning, the proportion of meat ranging from about 55% to almost 100%.

293. Despite the view that the amount suggested would be insufficient to cover up unhygienic manufacture, we are of the opinion that the use of a preservative would not be consistent with the policy of ensuring a high standard of hygiene. We believe that under conditions of good commercial practice it should be possible to protect this product from contamination without the addition of a preservative. We therefore recommend that this proposal should not be accepted.

Pectin

294. Representations have been made for permission to use sulphur dioxide in liquid pectin sold by retail for jam making and other purposes in the home. The product is pasteurised at 160°F., but the pectin will not withstand sufficient heat to destroy spores and thermophilic bacteria. Bottles of liquid pectin are likely to remain in retailers' hands for long periods and also are liable to deterioration once the bottle has been opened in the home.

295. We consider there is justification for allowing a preservative in this product and recommend that provision be made for liquid pectin to contain not more than 250 p.p.m. of sulphur dioxide; this is the limit suggested by the manufacturers.

Rennet

296. A somewhat similar application relates to the use of a preservative in bottled liquid rennet sold by retail. Despite steps taken during processing to reduce the bacterial count, the essence is liable to deterioration both during

storage in retail premises and during the time the bottle is in use in the home. Glycerine is at present incorporated in the essence in an attempt to control the growth of organisms, but this is not entirely satisfactory and it is requested that up to 3,000 p.p.m. of sodium benzoate should be allowed. It is pointed out that such an amount will give only about 20 p.p.m. in junket as consumed.

297. We accept that the addition of a preservative to domestic rennet is justified but consider that it should be possible to obtain adequate preservation with not more than 2,000 p.p.m. of benzoic acid.

Food Additives

298. Representations have been made for permission to use a preservative in permitted liquid food colours and in certain anti-foam agents. In the case of food colours, an adequate shelf-life is necessary, particularly for culinary colours sold by retail, and mould growth cannot be prevented adequately by other means. It is suggested that they should be allowed to contain 2,000 p.p.m. of benzoic acid. As we noted in our report on emulsifying and stabilising agents, silicone emulsions are being increasingly used as anti-foam agents in certain food manufacturing processes. It is suggested that to give these emulsions an adequate storage life they should be allowed to contain a preservative: sulphur dioxide (350 p.p.m.), benzoic acid, sorbic acid and various para-hydroxybenzoic acid esters are suggested as being suitable. One firm suggests that the use of any preservative in food additives of this kind, which are present in only very small amounts in foods, should be excluded from the application of the Regulations.

299. We see no objection in principle to the use of a permitted preservative in these food additives and we recognise that it will result in only minute traces in the food itself. Nevertheless, these additives are within the definition of food in the Food and Drugs Act, and we see objection to exempting them from the Regulations altogether, both on health grounds and because it would make enforcement even more difficult. We therefore consider that only preservatives permitted in other foods should be considered for inclusion in these additives, and recommend that liquid food colours and silicone anti-foam emulsions should be allowed to contain not more than 2,000 p.p.m. of benzoic acid or 1,000 p.p.m. of sorbic acid.

PART V: SUMMARY OF RECOMMENDATIONS

A. RECOMMENDATIONS FOR AMENDMENT OF THE REGULATIONS

(i) The definition of "preservative" for the purpose of the Regulations should be amended to clarify the intended scope of the Regulations and to amend the list of substances excluded from the definition (paragraphs 26–35).

(ii) The definitions of "food" and "human consumption" should be made to correspond with those in the Food and Drugs Act, 1955 (paragraph 36).

(iii) Regulation 4(I) should be replaced by a provision that no person shall sell, offer or expose for sale or have in possession for sale by retail any food containing a non-permitted preservative or a permitted preservative in excess of the amount specifically allowed (paragraphs 37 and 38).

(iv) A similar provision should apply to sales etc., other than by retail, and to importation, unless the food (being a Scheduled food or intended for use in the preparation of a Scheduled food, but not being fruit or fruit pulp for manufacturing purposes containing sulphur dioxide or a food which is pre-packed for retail sale) is accompanied by a statement in prescribed form of the actual content of permitted preservative (paragraphs 39–42).

(v) Provision should be made that food containing a non-permitted preservative may be treated as unfit for human consumption for purposes of Section 9 of the Food and Drugs Act (paragraph 43).

(vi) Regulation 4(1)(ii) should be replaced by a provision that any compound food (not being a Scheduled food) which contains one or more Scheduled foods (other than fruit and fruit pulp for manufacturing purposes and unfermented grape juice products for sacramental purposes) as ingredients may contain preservative of the nature and to the extent permitted in the Scheduled foods and in proportion to the amount of each Scheduled food which it contains (paragraphs 47–50).

(vii) A tolerance of 50 p.p.m. of sulphur dioxide should be allowed in any compounded food (not being a Scheduled food) permitted to contain sulphur dioxide by virtue of the previous provision (paragraphs 51–55).

(viii) The First Schedule should be amended to give effect to the recommendations made in Part IV of the report (and paragraph 102) and summarised in the following table:

Scheduled Food	*Preservative permitted*	*Maximum amount permitted (parts per million)*
Wine (paragraph 203)	sulphur dioxide	450
Beer (paragraph 198)	sulphur dioxide	70
Cider and perry (paragraph 201)	sulphur dioxide	200
Soft drinks for consumption after dilution and soft drinks having a comparable carbohydrate content for consumption after or without dilution (paragraph 177)	sulphur dioxide or benzoic acid	350 800
Other soft drinks for consumption without dilution (paragraph 204)	sulphur dioxide or benzoic acid	70 160
Fruit juices, sweetened or unsweetened, whether concentrated or not (paragraph 177)	sulphur dioxide or benzoic acid	350 800
Unfermented grape juice products for sacramental purposes (paragraph 168)	benzoic acid or methyl- or propyl-p-hydroxybenzoate	2,000 2,000
Vinegar (paragraph 290)	sulphur dioxide	70
Bread (paragraph 241)	propionic acid	0·3% of flour weight
Flour confectionery (paragraph 245)	sorbic acid	1,000
Cheese (paragraphs 268 and 272)	sorbic acid or nisin	1,000 (a)
Citrus fruit (paragraphs 229 and 231)	diphenyl or ortho-phenylphenol	100 70
Fruit and fruit pulp (other than tomato pulp) for manufacturing purposes (paragraph 162)	sulphur dioxide	3,000
Tomato pulp (paragraph 163)	methyl- or propyl-p-hydroxybenzoate	900
Dried fruit, including raisins and sultanas (paragraph 167)	sulphur dioxide	2,000

Scheduled Food	*Preservative permitted*	*Maximum amount permitted (parts per million*
Crystallised and glacé fruit (paragraph 182)	sulphur dioxide	100
Candied peel and cut and drained (syruped) peel (paragraph 182)	sulphur dioxide	100
Syruped fruit (paragraph 182)	sulphur dioxide	100
Fruit and fruit pulp not elsewhere specified (paragraph 186)	sulphur dioxide	350
	or benzoic acid	800
Raw peeled potatoes (paragraph 264)	sulphur dioxide	50
Dehydrated potato (paragraph 218)	sulphur dioxide	550
Dehydrated cabbage (paragraph 218)	sulphur dioxide	2,500
Other dehydrated vegetables (paragraph 218)	sulphur dioxide	2,000
Bacon and ham (paragraph 224)	sodium nitrate	(a)
	and sodium nitrite	(b)
Cooked pickled meat (paragraph 225)	sodium nitrate	(a)
	and sodium nitrite	200
Uncooked pickled meat (paragraph 226)	sodium nitrate	(a)
	and sodium nitrite	500
Sausages and sausage meat (paragraph 153)	sulphur dioxide	450
Butchers' minced meat (c) (paragraph 155)	sulphur dioxide	450
Sugar and sugar syrups (paragraph 188)	sulphur dioxide	70
Solid hydrolysed starch (paragraph 188)	sulphur dioxide	70
Hydrolysed starch syrups (paragraph 191)	sulphur dioxide	450
Prepared starches (paragraph 189)	sulphur dioxide	100
Jam, including preserves sold for special dietetic purposes (paragraphs 179 and 181)	sulphur dioxide	100
Marzipan (paragraph 287)	sorbic acid	1,000
Gelatin (paragraph 192)	sulphur dioxide	1,000
Liquid pectin (paragraph 295)	sulphur dioxide	250
Liquid rennet (paragraph 297)	benzoic acid or	2,000
	methyl- or propyl-p-hydroxybenzoate	2,000
Flavouring syrups (paragraph 274)	benzoic acid or	800
	methyl- or propyl-p-hydroxybenzoate	800
Liquid coffee (or coffee and chicory) extract (paragraph 207)	benzoic acid or	450
	methyl- or propyl-p-hydroxybenzoate	450
Drinking chocolate concentrate (paragraph 281)	benzoic acid or	700
	methyl- or propyl-p-hydroxybenzoate	700
Pickles and sauces (paragraph 211)	sulphur dioxide	100
Dry root ginger (paragraph 283)	sulphur dioxide	150
Solutions of permitted food colours (paragraph 299)	benzoic acid or	2,000
	sorbic acid	1,000
Silicone anti-foam emulsion (paragraph 299)	benzoic acid or	2,000
	sorbic acid	1,000
Canned foods as defined (paragraph 279)	nisin	(a)

Notes: (a) no statutory limit recommended

(b) no statutory limit recommended pending review—see recommendation (xiv)

(c) applicable to Scotland only and limited to the months of June, July, August and September.

(ix) Provision should be made that where, as indicated in the above table, an alternative preservative is allowed and a mixture of preservatives is used, the amount of each preservative present shall be such that, when expressed as a percentage of the amount respectively permitted, the sum of the two does not exceed 100 (paragraphs 44 to 46).

(x) Provision should be made for the use of alternative forms of permitted preservatives as indicated in Part III of the report and summarised in the following table:

Form of preservative to which the limits apply	*Alternative forms in which the preservative may be used in appropriate amounts*
sulphur dioxide	sulphurous acid and sodium, potassium and calcium sulphites
benzoic acid	the sodium and potassium salts
sodium nitrate	potassium nitrate
sodium nitrite	potassium nitrite
ortho-phenylphenol	the sodium salt
methyl-p-hydroxybenzoate	the sodium salt
propyl-p-hydroxybenzoate	the sodium salt
sorbic acid	the sodium salt
propionic acid	the sodium and calcium salts

(xi) Specifications of purity should be prescribed for permitted preservatives (paragraph 151).

B. OTHER RECOMMENDATIONS

(xii) Arrangements should be made for keeping under review the use of preservatives in food and for advising on such further changes in the Regulations as may be necessary from time to time (paragraph 23).

(xiii) The provision of the Regulations dealing with the labelling of preservatives and of foods containing preservative should be considered during a review of the Labelling of Food Order (paragraphs 56–59).

(xiv) Further consideration should be given to regulating the nitrite content of bacon and ham as soon as the necessary technical evidence is available (paragraphs 219–224).

FSC/PVT/REP 6 *February,* 1959

APPENDIX I

List of those who have submitted evidence or been consulted

Association of Municipal Corporations
Association of Public Analysts
County Councils Association
Society of Medical Officers of Health
Malden and Coombe Borough Council
Chief Port Health and Food Inspector, Harwich
Chief Public Health Officer, Dundee
Medical Officer of Health, Southampton
Health Committee, Birmingham Corporation

Association of British Chemical Manufacturers
Association of British Pharmaceutical Industry
Association of Manufacturers of Shortening and Compound
*Brewers' Society
*British Bacon Curers' Federation
*British Baking Industries Research Association
British Chemicals and Dyestuffs Traders' Association
*British Essence Manufacturers' Association
*British Food Manufacturing Industries Research Association
British Glucose Manufacturers' Association
British Trawlers' Federation Limited
British Turkey Federation
Cocoa, Chocolate and Confectionery Alliance
*Flavouring Compound Manufacturers' Association
*Food Manufacturers' Federation Incorporated
Fruit and Vegetable, Canning and Quick Freezing Research Association
Galston, Strathaven, Newmilns and Darvel etc. Butchers' Association
Hull Trawler Officers' Guild
Invert Sugar Manufacturers' Association
Joint Executive Committee of Margarine and Compound Cooking Fats Manufacturers
Margarine Manufacturers' Association
Master Butchers' Association, City of Londonderry
National Association of Creamery Proprietors and Wholesale Dairymen
National Association of Master Bakers, Confectioners and Caterers
National Association of Soft Drinks Manufacturers
National Association of Poultry Packers Limited
National Farmers' Union
National Federation of Fish Quick Freezers
National Federation of Meat Traders' Associations
National Research Development Corporation
Pharmaceutical Society of Great Britain
*Potato Marketing Board
Scottish Federation of Meat Traders' Associations
Tomato and Cucumber Marketing Board
U.S.A. Raisin Administrative Committee

White Fish Authority

Aktiebolaget Revmersholms Livsmedel
A/s Margarincentralen of Oslo
Barton's Cooperage
Beddington Nut and Produce Company Limited
Beecham Foods Limited
F. W. Berk and Company Limited
J. Bibby and Sons Limited
Birds Eye Foods Limited
Birkett and Bostock Limited
*Borax Consolidated Limited
Brainos and Company Limited
British and American Salmon Curing Company Limited
British Celanese Limited
British Cellophane Limited
British Sugar Corporation Limited
H. P. Bulmer and Company Limited
H. W. Carter and Company Limited
Coleman and Company Limited
Corn Products Limited
Alfred P. Cumming Limited
Cyanamid of Great Britain Limited
C. Czarnikow Limited
Distrifoods Limited
East Kent Packers Limited
East Norway Canning Company Limited
Express Dairy Company (London) Limited
Flip Limited
R. J. Fullwood and Bland Limited
Geigy Company Limited
Gemec Chemicals Company
Golden Block Limited
Grimsby Fish Meal Company Limited
Grimsby Ice Company Limited
Guest Industrials Limited
Hector Whaling Limited
Hoechst Chemicals Limited
Hull Fish Meal and Oil Company Limited
Hull Ice Manufacturing Company Limited
Imperial Chemical Industries Limited
Ind Coope and Allsopp Limited
Mac Fisheries Limited
Marks and Spencer Limited
Midland Silicones Limited
Milton Antiseptics Limited
H. A. Moller (London) Limited
Monsanto Chemicals Limited
M.P.P. (Products Limited
Newball and Mason Limited
Newhall Dairies Limited
Nipa Laboratories Limited
Odense Marzipan Factory
Pfizer Limited
*J. Sainsbury Limited
Chr. Salvesen and Company
P. Samuelson and Company
E. E. Smith and Brian Smith (1928) Limited
W. M. Still and Company Limited
Taminiau's Conservenfabrieken N.V., Netherlands
Tate and Lyle Limited
T.M.V. Limited
Transparent Paper Limited
Trawlers Grimsby Limited

*Unilever Limited
Wallace and Tiernan Limited
D. C. Watson and Sons
Royal Netherlands Embassy
Senior Government Trade Commissioner, Commonwealth of Australia
University of Bristol

H. Amphlett Williams, Esq., Ph.D., A.C.G.F.C., F.R.I.C.
F. C. Bullock, Esq., B.Sc., F.R.I.C., P.A.Inst.W.E.
T. McLachlan, Esq., A.C.G.F.C., F.R.I.C., M.I.Biol.
E. C. Wood, Esq., Ph.D., A.R.C., F.R.I.C.

*These organisations also gave oral evidence

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APPENDIX III

Estimation of the Dietary Intake of Sulphur Dioxide

1. At the request of the Sub-Committee, the Association of Public Analysts obtained data from 22 public analysts serving food and drugs authorities throughout England and Wales relating to foods examined during the previous two or three years for their sulphur dioxide content. These results are summarised in Table A. In some cases the number of samples is small, and for a number of reasons the results may not be representative of the actual range of foods on sale, but the general picture given by the table is considered to be a sufficiently reliable guide.

TABLE A

Scheduled Food	*Number of samples*	*Proportion of samples reported as negative*	*Estimated average SO_2 content of positive samples*	*Estimated average SO_2 content of all samples*
Item		%	*p.p.m.*	*p.p.m.*
1. Sausages and sausage meat	1,078	51	230	113
3a. Dried apricots etc.	70	50	804	402
3b. Raisins and sultanas	125	52	546	262
5. Concentrated soft drinks	546	37	183	133
6. Jam	311	55	27	12
8. Sugar etc.	All below 10 p.p.m.—usually reported negative			
10. Gelatin	89	46	212	115
11. Beer	106	35	34	22
12. Cider	11	nil	96	96
13. Wine	118	67	135	45
14. Mineral Waters	Majority negative; a few positive samples 8–68 p.p.m.			
18a. Dehydrated potatoes	A few positive samples 330–690 p.p.m.			

2. The sulphur dioxide content of some Scheduled foods in known to be further reduced on cooking. Laboratory experiments by the Scientific Adviser's Division (Food) indicated that sausages and sausage meat when fried may lose up to a half of their sulphur dioxide content, that dried fruit when stewed loses between 30% and 55% and that gelatin, in the form of jelly tablets, loses most of its sulphur dioxide during preparation.

3. Using these data as an appropriate measure of the average quantity of sulphur dioxide likely to be present in the various foods as consumed and with estimates of the average amount of these foods consumed per head, it is possible to

make a rough calculation of the possible dietary intake of sulphur dioxide. The National Food Survey for 1953 provides data on the weight of some of the Scheduled foods which were purchased for consumption by the average household. For the other Scheduled foods, Consumption Level Enquiry, 1953, estimates had to be used. The two sets of data are not strictly comparable, nor do some of the categories exactly coincide with items in the Preservatives Regulations; the calculations cannot therefore be precise. They are, however, the best estimate that can be made on the information available. The results are set out in Table B. No allowance is made for other foods which may contain sulphur dioxide by virtue of the "carry-over" clause, but the amount ingested in this way must be very small. Where figures for the actual sulphur dioxide content of Scheduled foods are not available, as with crystallised fruit, fruit and fruit pulp and cornflour, the maximum amount permitted has been assumed.

TABLE B

Food	*Average weight of food consumed per head per day*	*Approximate quantity of SO_2 likely to be consumed*
National Food Survey Data	*g./day*	*mg./day*
Sausages and sausage meat	14	1·3
Dried fruit	1	0·3
Raisins and sultanas	4	1·0
Jam	15	0·2
Crystallised etc. fruit	<1	—
Fruit and fruit pulp	3	1·0
Sugar	60	0·6
Cornflour	3	0·3
Fruit juices	<1	0·1
Add 10% for food eaten in catering establishments	—	0·5
Consumption Level Enquiry Data		
Wine	4	0·2
Cider	14	1·4
Beer	213	4·7
Soft drinks	130	3·1
Jelly tablets	2	0·2
Total	—	14·9

4. It will be seen that the estimated intake of sulphur dioxide is of the order of 15 mg. per head per day on the basis of the existing Regulations. The Sub-Committee's proposals involve some extension in the use of sulphur dioxide although most of the changes would have only a marginal effect on the dietary intake. The increase in the limit for raisins and sultanas (from 750 p.p.m. to 2,000 p.p.m.) and the new limit for pickles and sauces (100 p.p.m.) would not contribute more than about 2 mg. of sulphur dioxide. Similarly, the proposed limit of 50 p.p.m. for raw peeled potatoes (including chips) would only contribute about 2 mg. of sulphur dioxide if *all* potatoes were treated. This is clearly an outside estimate. Thus, with the necessary reservation due to the limitations of the data, it can be said that the total intake of sulphur dioxide on the basis of the limits recommended by the Sub-Committee is unlikely to exceed 20 mg. per day.

APPENDIX IV

REPORT OF THE ANTIBIOTICS PANEL

Consumer Hazards of Chlortetracycline, Oxytetracycline and Nisin as Preservatives

INTRODUCTION

1. The Panel was appointed in 1956 to:

"advise the Preservatives Sub-Committee of the Food Standards Committee and the Scientific Sub-Committee of the Advisory Committee on Poisonous Substances used in Agriculture and Food Storage, on the extent of the health hazard involved in the use of such antibiotics proposed for the preservation of food or for use in agriculture as are referred to it by each Sub-Committee".

2. The members of the Panel during the preparation of the report were:

G. A. Clark, Esq., C.B., V.R.D., M.D. (Chairman)
R. de Brath Ashworth, Esq., Ph.D., A.R.I.C.
Professor L. P. Garrod, M.A., M.D., B.Ch., F.R.C.P.
J. M. Johnston, Esq., C.B.E., M.D., F.R.C.P.(Ed.), F.R.C.S.(Ed.), F.R.S.E.
Professor A. Kekwick, M.A., F.R.C.P.
H. E. Magee, Esq., D.Sc., M.R.C.P.
G. S. Wilson, Esq., M.D., F.R.C.P., M.R.C.S., D.P.H.

3. The following constitute the Secretariat:

W. T. C. Berry, Esq., M.D., M.A., D.T.M. and H.
W. A. Godby, Esq., M.B.E., F.R.I.C.
E. J. Miller, Esq., B.Sc., Ph.D.

OXYTETRACYCLINE AND CHLORTETRACYCLINE (THE TETRACYCLINES)

Proposed Uses:

4. It has been proposed:

(a) that fowls eviscerated at packing stations should be placed in cooling tanks of ice-water containing 10–20 p.p.m. of a tetracycline for about two hours. Subsequent storage would be at about 37°F. (3°C.). Turkeys would be similarly treated but would need longer time for cooling in the tetracycline ice-water;

(b) that a tetracycline should be incorporated at a concentration of 5 p.p.m. in the ice used to store fish in the holds of trawlers: and/or that fillets of fish should be dipped for about a minute in solutions containing 10 p.p.m. of a tetracycline;

(c) that 25 g. of a tetracycline should be included in the explosive head of the harpoon used to kill whales; and/or 10 gallons of water containing 55 g. of a tetracycline be introduced in atomised form when air is blown into the peritoneal cavity to make the whale float.

EVIDENCE

5. The Panel considered: representations to the Preservatives Sub-Committee by industrial concerns; other evidence supplied by these concerns; information supplied by the D.S.I.R. Low Temperature and Torry Research Stations; published evidence; work done for the Panel by one of its members, Professor Garrod; information from the Food and Drugs Administration in the United States. Points of particular interest are noted below.

6. **Degradation on cooking**—Chlortetracycline is largely broken down by the heat of cooking, it is thought to isochlortetracycline; the degradation products of oxytetracycline found to date on cooking have been inactive esters and similar derivatives.

7. **Active residues in poultry**—With the method of treatment proposed (paragraph 4(a)) the amount of tetracycline in the treated raw poultry is generally of the order of 1–2 p.p.m. but may occasionally be as much as 6 p.p.m.

The residuum of active tetracycline after cooking by ordinary methods ranges from amounts too small for detection to 0·4 p.p.m. As a rule, concentrations of 0·4 p.p.m. are only found in the skin of the bird.

8. **Active residues in fish**—The amount of tetracycline taken up, both by gutted whole fish or by fillets, varies considerably, particularly in the skin. Evidence presented to us by the Torry Research Station indicates that an important factor in this variation is the downward migration of chlortetracycline from the ice into the packed fish, so that the upper side skin of the fish contains more antibiotic than the under side skin. This difference is observable also in the subdermal tissue and muscle, though the highest amounts are always found in the skin, which may contain up to 10 p.p.m. even after washing. The effect of boiling, steaming and frying fish is a destruction of all antibiotic in fish muscle and about two-thirds of the antibiotic in the skin. The skin of baked fish contains a greater concentration of antibiotic than does the raw skin; we presume that though some destruction may have taken place as with other cooking methods, the skin itself has become drier. The Torry Research Station are continuing their studies on the residual antibiotic in cooked fish.

9. **Active residues in whales**—Evidence on what may occur in commercial practice is scanty, but as far as it goes it indicates that negligible residues remain in the flesh of whales treated with tetracyclines. The amounts proposed for use are only about 1-2 millionths of the animal's weight. Laboratory tests on whale oil and whale meat extract to which 5 p.p.m. chlortetracycline had been added indicated that the processing to which these products are subjected would effectively remove all the antibiotic.

10. **The development of resistance in organisms subjected to low concentrations of tetracyclines**—We know of no published evidence on the development of resistance in food poisoning organisms exposed to the very low concentrations

of tetracyclines associated with their use as preservatives. But one of us, Professor L. P. Garrod, on our behalf cultured staphylococci 28 times in broth containing 0·1 μg. per ml. of tetracycline. Originally growth was inhibited by 1 μg. per ml. By the time the study was finished, resistance of strains had risen so that concentrations of 8 and 16 μg./ml. were needed to inhibit growth. In a second study Professor Garrod carried out 35 transfers in broths containing 0·02 and 0·005 μg./ml. of chlortetracycline. The latter concentration had no effect but organisms exposed to 0·02 μg./ml. increased in resistance to a small extent, from 0·25 to 2·0, and from 0·25 to 1·0 μg. per ml. From these studies some indication may be got of a threshold at which resistance is enhanced.

11. **Hypersensitivity**—Established cases of sensitisation to tetracylines are extremely rare despite their widespread medical use, and their use in agricultural feeding (whereby the skin of the user may frequently be in contact with small amounts), and their large scale production in which many workers are concerned. In the United States one person, proved to be hypersensitive to chlortetracycline, has prepared and eaten treated chicken without ill effects.

12. **Conditions under which contamination by resistant pathogens may occur**—Of particular note is the common practice of feeding growing poultry destined for table use with mashes containing low levels (4–30 p.p.m.) of one or other tetracycline, in order to promote rapid growth. In pigs it has been clearly shown (Williams, Smith and Crabbe, Vet. Record, **69**, 24, 1957) that this practice may lead to a replacement of sensitive organisms in the bowel by resistant strains of the same organism (in this case Bact. coli.). These findings in pigs suggest that bacteria harboured by some poultry may come to be predominantly resistant, and in fact unpublished work by Dr. Betty Hobbs indicates that resistant salmonellae may increase in prevalence as a result of the practice of feeding antibiotic-containing mashes to poultry.

DISCUSSION

(a) Possibilities of Bacterial Food Poisoning

13. A potential hazard is that the use of tetracyclines as preservatives may enhance the risk of bacterial food poisoning. On the one hand their presence in food checks the normal growth of spoilage organisms, rendering the food in effect a selective medium for resistant pathogens. On the other hand conditions exist which favour the access of such strains to treated food. Some bacterial contamination of the flesh from the gut of slaughtered poultry is unavoidable, and, as already noted, the practice of feeding antibiotic mashes during the growing period increases the likelihood of these organisms being resistant. It is thought that many of the organisms which normally cause spoilage reach the packing station on the feathers and feet of birds, but these would not be rendered resistant in the same way. Again, the medical uses of antibiotics have led to an increase in the number of people harbouring antibiotic-resistant pathogens, so that food handlers might contaminate food preserved by antibiotics. Some spoilage organisms developing in the plant itself may become resistant. A treated bird would not then be a selective medium for pathogens, but to the extent to which this occurs, the purpose of the treatment is vitiated.

14. The risks of food becoming contaminated are increased by bad hygiene, and antibiotics, by checking spoilage, may reduce a major incentive towards good hygiene (vide infra).

15. Whilst salmonellae, multiplying on poultry flesh, would be killed by thorough cooking, this does not always occur. Also, it is our experience that

as a result of handling in shops, foods already cooked can on occasion become infected from raw contaminated food, and can thus cause food poisoning.

16. If the poultry were kept sufficiently cold from the time of treatment to the time it is to be cooked, the hazard of food poisoning would not of course arise. But, in practice, treated birds may frequently be kept after retail sale at temperatures at which pathogens can multiply; relatively few British homes have refrigerators. More evidence is required before it will be possible to assess whether and to what extent tetracycline treatment can create a new risk of food poisoning.

(b) Standards of Hygiene

17. Where tetracyclines are used on poultry in the United States, and on fish in Canada, the producers of the antibiotic operate a "franchise" system, whereby antibiotic is made available only to those packing stations, plants, or ships, which conform to certain standards of hygiene. This is because, according to the producers, tetracyclines as preservatives are most effective where hygiene is good. How effectively such a scheme operates to prevent lapses of hygiene, listed above as a factor contributory to the hazard of bacterial poisoning, and to what degree such a system would be practicable or desirable in this country, we are unable to say. In theory at least, some much-needed hygienic measures could thereby be brought about. On the other hand, there are obvious difficulties in supervising the hygiene of the fish industry, which might deteriorate because, as already noted, the use of tetracyclines as preservatives might reduce the effectiveness of an existing incentive to good hygiene.

(c) The development of resistant strains in the consumer's bowel

18. Professor Garrod's work shows that resistant strains of organisms may develop as a result of exposure to very low concentrations of tetracycline. It indicates also that there may be a threshold below which, at least in the case of staphylococci, resistant strains do not emerge; but to what degree this may apply to other organisms, and to intermittent exposure resulting from the consumption of food treated with tetracyclines, is uncertain.

(d) Hypersensitivity

19. Separate consideration has to be given to the potential hazard of reactions arising in persons already sensitised to tetracyclines, when consuming treated foods. For this two things are needed: that individuals should become sensitised to tetracyclines, which happens only very rarely; and that they should react hypersensitively when eating treated food, which has never been shown to occur, and in one instance has been shown definitely not to occur. Nevertheless this theoretical hazard does exist, and it should be remembered that when treated food is consumed, it may not only be the amount of active antibiotic that is important, as the consumer might also be sensitive to some at least of the inactive degradation products.

(e) Relationship between hazards and the amount of tetracycline used

20. Because particularly of the theoretical risk of sensitivity, and of the possibility of the development of resistant organisms in the consumer's intestine, it is in our view desirable that food as consumed should contain practically no antibiotic.

21. In the U.S.A. a maximum of 7 p.p.m. of tetracycline is permitted in raw poultry, and this tolerance level must not be exceeded in any part of the poultry. As noted above, the cooked bird usually contains no detectable antibiotic, though very occasionally levels up to 0·4 p.p.m. have been found in the skin of the cooked birds. We hold that poultry treated as in the U.S.A., and cooked, may be regarded as containing "practically" no antibiotic.

22. We cannot with the same confidence regard the residues which from the evidence so far available seem likely to be present in fish after cooking. Appreciable quantities may only be present in the skin, but its presence cannot be ignored as the skin of many varieties is often eaten. We are not satisfied, on the evidence available to date, that the consumption of fish treated with tetracyclines is free from medical disadvantages.

23. The consumption of whale meat extract or whale oil products derived from treated whales is in our view safe, provided the processing is of a nature by which all antibiotic is destroyed.

CONCLUSIONS

24. We therefore advise that:

(i) If eviscerated poultry, containing not more than 7 p.p.m. in any part of the raw bird, of chlortetracycline or oxytetracycline, are kept from the time of treatment to the time of cooking at temperatures of 3°C. or less, there is on the basis of available evidence, no hazard to the consumer, but the present evidence is insufficient to assess what degree of hazard from food poisoning may exist if the temperature is not thus maintained throughout.

(ii) The possibility of medical disadvantages attending the use of tetracyclines on fish, has not yet been wholly excluded.

(iii) Whale meat extract and whale oil products derived from tetracycline-treated whales do not present a hazard if the processing is of a nature by which all antibiotic is destroyed.

NISIN

Proposed Uses

25. Proposals have been submitted that nisin be added to:

(a) cheese, including processed cheese, and cheese spreads;
(b) evaporated milk;
(c) sterilised cream;
(d) canned clotted cream;
(e) chocolate milk;
(f) canned cream soups;
(g) canned meat soups;
(h) canned vegetable soups;
(i) the following canned vegetables: macedoine, beans with tomato, beans with pork, beetroot, processed peas, garden peas, carrots, turnips and potatoes;
(j) the following canned fruits, either whole, or as puree or juice: pears, pineapples, peaches, figs, prunes, plums and tomatoes;
(k) canned sausages;
(l) canned fish, viz., salmon, sardines in tomato or in brine, pilchards in tomato or in brine, tuna, herrings in tomato or in brine, mackerel, fish roes;

(m) canned formulations, with or without milk and cheese, of rice, spaghetti, and macaroni.

26. We have been told of the possibility that the following imported products may be treated with nisin during manufacture or processing even though some may contain none on import:

(n) low acid soft cheese, viz., Gruyere, Emmenthal, Edam, Gouda, Samsoe, Tilsiter, Herrgard, etc.;
(o) hard cheeses, viz., Parmesan, Grana, etc.;
(p) canned olives in brine.

EVIDENCE

27. Information was supplied to us to the effect that:

(i) Nisin is produced by a number of strains of a cheese starter organism, *S. lactis*, and is naturally present in certain cheeses.
(ii) Nisin is a "medically rejected antibiotic". Bacteria which acquire resistance to nisin do not thereby acquire cross-resistance to antibiotics in medical use. It has a narrow spectrum, and is inhibitory to Staph. aureus and Cl. welchii but not to salmonellae. Clostridia are sensitive to it, though some strains of Cl. botulinum have been stated to be resistant (Morrell, C. A. and Thatcher, F. S., Food, Drugs and Cosmetic Law Journal, 1957, p. 486) and its value as a preservative in food is largely in the control of clostridial spores which multiply in certain cheeses and in other products leading to blowing or "hard swells".
(iii) Nisin is a polypeptide which on hydrolysis yields amino-acids only of laevorotatory form. It is digested by trypsin.
(iv) Experiments on animals and man show that very high levels can be fed without ill effects.

28. We understand also that:

(i) The use of nisin in processed cheese does not enable the manufacturer to process decomposed or unwholesome cheese because this does not produce a satisfactory product.
(ii) If processing and packing is unhygienic, nisin is often destroyed by contaminants.
(iii) When nisin is added in amounts sufficient to control spoilage by thermophilic organisms, the residual nisin in products (b), (c), (d) and (e) above, after processing, would be of the order of 0·1–0·3 p.p.m. which would disappear on prolonged storage. In products (f), (g), (h) and (i) the residues after processing are of the same order, and disappear within a few weeks of storage. In canned fruit it is of the order of 2 p.p.m. disappearing in 6–8 weeks. In products (k) and (l) the residuum is 0·1 p.p.m. or less. In product (m) the residuum is about 0·3 p.p.m. disappearing within 2–3 weeks.

DISCUSSION

29. Nisin is a natural product of certain cheeses, and there is nothing to suggest that harm has resulted from its presence. Nor, from the information supplied to us, does it seem likely that harm will in any way arise from the addition to cheese of nisin either in a comparatively pure state or as a constituent of "high nisin cheese" (i.e. cheese produced in such a way that large amounts of nisin are naturally produced in the course of fermentation).

30. With other products the position is different. Though most strains of clostridium botulinum are sensitive to nisin, not all are. Therefore any reduction

in times and temperature of processing, arising out of the use of nisin, could reduce the margin of safety from botulism.

31. In considering the other products for which proposals have been made, we have had to bear in mind that any relaxation of the Preservative Regulations would apply not only to British manufacturers, who wish to maintain the high reputation of canned goods, and would therefore ensure that the method of processing was sufficient to destroy Cl. botulinum spores, but also to importers, not all of whom may be so meticulous.

32. Therefore the possible uses of nisin listed above under heads (b) and (p) fall logically into certain main groups:

(a) Certain foods have, in order to be acceptable to the consumer, to be subjected to high enough temperatures for long enough periods to reduce the chance of survival of Cl. botulinum to 10^{-11}, or less (F_3). In such cases there is an automatic safeguard against botulism; nisin merely does away with the need to use the much higher temperatures that are necessary in order to control spoilage due to thermophilic organisms. Evidence was provided for us that the following products had been processed experimentally at a value of F_3 only. Under these conditions none of the products listed was marketable on account of under-cooking.

Soups: cream of tomato, cream of mushroom, cream of asparagus, pea, mixed vegetable, onion, chicken, ox-tail, lentil.

Vegetables: macedoine, beans with tomato sauce, beans and pork, beetroot, garden peas, processed peas, carrots, turnips, potatoes.

Meat products: chipolata sausages, frankfurters, stewed steak.

Fish products: pilchards in tomato, mackerel.

(b) With some other products, e.g. olives, an acceptable article may be produced by processing below F_3 and the presence of nisin might increase the chance of botulism. It is possible that olives treated with nisin may be imported into this country regardless of any regulations on the subject; since at the time of import no nisin would be present, control might be very difficult unless based on a system of licensing.

(c) Foods which do not need processing at F_3 or above but which are sufficiently acid to preclude the risk of botulism. No evidence was produced for us that the fruits listed under item (j) in paragraph 25 needed to be processed at high and prolonged temperatures in order to be acceptable to the consumer, and we assume that they do not. But we consider that no hazard of botulism arises in products of pH less than 4·5.

(d) Canned milks and creams where it is likely that processing needs in any case to be sufficient to destroy Cl. botulinum spores, because of the risk of spoilage by mesophiles if it is not. In such cases no hazard arises provided this is carried out after the can is sealed. In the case of clotted cream it is suggested that heat processing should be carried out before canning. Before assessing the hazard, if any, of this we would need detailed information in the process proposed.

(e) Foods in which destruction of all mesophiles cannot be assured by processing, such as brawn, ham and sausages. Here nisin might, by suppressing the growth of other organisms, permit the growth of salmonellae. Nisin added to gelatin might exert similar effects if the gelatin were added to open meat products. We should add that no proposals for such uses have been submitted to us.